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THE DENTITION OF BRITISH MOLLUSCA.

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(*With a Tinted Plate.*)

By way of preface, it will be well to remind the reader that the class *Mollusca* admits of a general subdivision into *Acephalous* and *Encephalous* animals, the latter alone possessing heads. And although it by no means follows that they should therefore possess teeth, or that their headless relations should not have these useful instruments, yet it is among the *Encephala*, or *Gasteropods*, that we find the subjects of our present observations. These creatures are also, for the most part, occupants of a single shell, such as that of the whelk and the limpet, but some, as the land-snails and the beautiful nudibranchs of the ocean, are naked.

The *teeth* of a Gasteropod do not answer to the ordinary signification of the term. They are organs of trituration and abrasion indeed, but are not used for the purposes of holding or biting. Many of the shell-less mollusks have one or more horny mandibles; and in some instances these are replaced, and even supplemented, by buccal plates armed with spines. Such is the case with the genus *Natica*, and with *Cypræa Europæa*. And Woodward states, that many of the flesh-eaters have a spiny collar at the end of their flexible proboscis. These afford the means of holding the food or prey, while, what I have here termed teeth, are employed in rasping it into the mouth. The so-called teeth are silicious plates of extreme tenuity, often beautifully outlined and curved, and frequently serrated at their edges. There are generally a great number of them, sometimes many thousands, in one animal; and they are rooted in a thin membrane, named, from its form and position, the *dental* or *lingual ribbon*. As this lingual band forms a very interesting object for the microscope, and only requires a little

practice for its preparation, I will briefly describe the process, in the hope that some of my younger readers may be induced by its easiness to attempt it.

There need be no lack of subjects for examination. Periwinkles, whelks, and limpets are to be obtained in most places, even inland; but if these sea "fish" are not to be had, then every ditch will yield *Limnæi* and *Planorbes* in abundance, or, as a last resource, the common snails and slugs of the garden and the lane must serve the turn. The apparatus may be the simplest possible. One or two ordinary needles and as many surgical ones may be fixed into cedar pencil-sticks, or, better still, into the neat little bone holders used by ladies for their crochet-hooks. A few sharp pins will be required to hold down the parts. A common pocket-lens must be mounted so as to slide on an upright rod (a piece of soft wood stuck into a flat bit of lead will answer every purpose), for the dissection necessitates some magnifying power and both hands must be free. It will also be well to have a pair of small curved-pointed scissors, and a pair of forceps with claw-ends. They will be wanted for the larger mollusks; but in many instances the needles only can be used, on account of the great delicacy of the operation. The prime requisites are patience and light fingers; and assuming that the observer possesses both, let us now proceed to work. Select for a first example a good-sized periwinkle. If he is alive, scald him for a second, and then you will not be haunted by any qualms about vivisection; but it will not matter for the nonce if your subject has been boiled and even salted. Break the shell with a smart blow, and disengaging the animal, pin him down with his *foot* or walking-surface underneath. Above, and in front, there will then be seen a loosish flap of skin: that is the *mantle*, and on turning it back, it will disclose the *rostrum* or muzzle. It has two little fleshy *tentacles* at the sides (corresponding to the horns of a snail), and a small nearly circular aperture at the extremity, which should be turned to the right. Now, cautiously insert the curved point of the scissors and lay open the cavity of the mouth, but take especial care not to injure its floor, where it is paved with the tongue and its wondrous armature of teeth. If they are in the way, pin back the cut edges, and, with the needles, lift out the lingual band. It comes away readily, and as all the teeth are reflexed it may be drawn out forwards without risk of injuring them. It will probably require cleaning, which is most conveniently managed under transmitted light. In some of the minuter examples, indeed, the whole process must be so done. To effect this, get a cigar-box; turn it on one side and make a clean hole in the upper one, half an inch in diameter. A small mirror, or piece of plain

glass blackened at the back, is to be placed inside at such an angle as to reflect the light through the hole. The object is then laid on a glass slide over the opening and cleaned with a camel-hair brush and distilled water.

Only a portion of the tongue is in use at any one time. This is nearly flat and is held in its place by projections of the membrane on either side. The posterior part descends obliquely behind the mouth, and is formed into a cylinder by being enclosed in a membranous tube, which peels off like the finger of a glove turned inside out, and allows the whole of the lingual ribbon to be displayed as a flat strap. If particles of tissue adhere to it, they may be carefully removed by the brush, or the curved needle. But being very delicate, the tongue is often liable to be torn, if held meanwhile by a hard point; for this purpose a bristle is a very handy tool. The front of the tongue is in some cases folded at its end, so that the part most in use is at a short distance from the extremity. This happens especially with the carnivorous species which bore through the shells of their prey. The teeth on this portion are frequently worn down and broken, and as it is essential to the well-being of the animal to have good teeth, the reserve so bountifnlly provided is brought gradually forward, the worn part being at the same time absorbed. Thus a continually new rasping surface is secured. Quite at the hinder end of the tongue the teeth become rapidly imperfect and rudimental; but it admits of doubt whether they are in the act of growing, since the lingual band would appear to be originally prepared of such a length as to last effective as long as its owner requires it. In our periwinkle, the spare portion will be found beautifully coiled up in the body of the animal on the right side. That of the common limpet passes backwards and downwards, doubling on itself in its course, and is more than twice as long as the mollusk.

The tongue itself is divided for convenience of description into longitudinal areas, which are crossed by the rows of teeth. Of the former there are five, distinguishable by the different characters of the teeth they bear; but they are not always all present. The teeth are consequently named the *median*, the *lateral*, and the *uncini*, although the latter are not necessarily more hooked than the others. The areas bearing the *uncini* have been called *pleuræ*. Since each row is a repetition of all the rest, the system of teeth admits of easy representation by a numerical formula, in which, when the *uncini* are very numerous, they are indicated by the sign ∞ (infinity), and the others by the proper figure. Thus, ∞. 5. 1. 5. ∞, which represents the system in the genus *Trochus*, signifies that each row consists of one median, flanked on both sides by five lateral teeth, and these again by a large number of *uncini*. When only

three areas are found, the outer ones are to be considered as the *pleuræ*, inasmuch as there is not unfrequently a manifest division in the membrane between them and the lateral areas; but never, as far as I have observed, between the latter and the median region. This arrangement is typical of a large class, having the formula 3.1.3, which embraces genera so dissimilar as *Cypræa*, *Aporrhais*, and *Natica*, together with the vegetable feeding *Littorinidæ*, and the operculated land and fresh water mollusks. Again, when only two areas exist, it seems probable that this is caused by the absence of the central ones, and the teeth should therefore be termed *uncini*. Such is the case with the *Bullidæ* and the allied bare-gilled family of the *Doridæ;* and this conjecture is confirmed by the fact, that in *Cylichna* and its nearest allies, which are transition genera, a minute central tooth is present.

This subject has been investigated by several naturalists; abroad, by Lovén and Troschel, and at home by Gray and Woodward, with a view to obtaining criteria for a systematic arrangement of *Gasteropodous Mollusca*. Up to the present time, however, their labours have only partially succeeded. The union under one formula of so many creatures widely differing in shell, anatomy, and habits, clearly indicates, that if the lingual ribbon contains generic characters, they have not yet been ascertained. At the same time, it does present differences which may offer collateral evidence in cases difficult of discrimination. It does not help us to separate carnivorous from phytophagous animals; but it seems possible to make use of it as a mark between species. For, in all the examples I have examined, there is a distinct difference between the tongues even of the most closely allied. *Chiton discrepans* is hard to tell from *C. fascicularis* by the outer parts alone; but the tongues are clearly distinct. *Patella athletica* may, it is said, be similarly divided from *P. vulgata*. The two British species of *Acmæa* afford remarkable differences. *Trochus ziziphinus* and the nearly allied *T. granulatus* is another case in point. On the other hand, the occurrence in *T. helicinus* of six laterals is one of the reasons which suggest a change in its generic name; and great lingual dissimilarity demands the separation of our two fresh-water *Ancyli*. In this way supposed varieties may be possibly decided. If, for instance, the lingual ribbon of the many subdivisions of *Litorina rudis* is constant in its characters, they cannot be received as species. Again, the position of the fluviatile *Paludinidæ* in close proximity to the sea-loving *Litorinidæ* is confirmed by the likeness of their dentition; while *Neritina fluviatilis*, with the formula ∞. 3. 1. 3. ∞, shows an approach to the genus *Trochus*.

All the land and fresh-water mollusks without opercula

show a great similarity in their dentition. Their tongues are "like a tesselated pavement," so regular are their numerous teeth. These are mostly rectangular in ground-plan, and armed with a single (or sometimes triple) recurved point. They are often so very minute, that their characters are barely discernible, even by the aid of the best lenses. When this happens, we may avail ourselves of the rule established by Mr. W. Thomson, who first in England directed attention to this subject. He found that the form of the whole transverse row corresponds to certain peculiarities in the teeth, to such an extent as to be an almost equally safe guide in questions of affinity. Thus, each row passes straight across the tongue in *Planorbis albus* and *vortex*, is curved in *Limax marginatus*, and suddenly bent in *Zonites cellarius*. Whence it may be inferred that the teeth are all similar in cases like the first named, and gradually or suddenly differ in the others respectively.

It is among the in-operculated members of the order *Pulmonifera* that we meet with the most astonishing instances of large numbers of teeth. *Limax maximus* possesses 27,000, distributed through 180 rows of 160 each. *Helix pomatia* has 21,000; and its comparatively dwarfed congener, *H. obvoluta*, no less than 15,000. When it is remembered that these estimates refer to series of forms, often elegantly curved and sculptured, the total area sustaining them not measuring at the utmost more than half an inch long and one-eighth broad, we must be filled with admiration at the marvellous prodigality of the great creative power thus bestowed upon such a small part of the organization of an humble snail. And when I ask my readers to examine these things for themselves under the microscope, I venture to think that the varied and beautiful outlines and serried ranks of these delicate amber-coloured atomies will be viewed with a delight whose depth and intensity the observers of nature can alone rightly measure.

The examples figured in the plate are drawn from original preparations,* and represent the principal types. And in the following table I have placed the genera known to me under their respective formulæ, as some guide to the student of these objects. The group characterized by the numbers 1. 1. 1 will be noticed as the best, the animals being all flesh-eaters, with the exception of, perhaps, *Lamellaria*. The generic names are those employed by Forbes and Hanley, in their *British Mollusca*.

* Those of Lamellaria, Doris, Goniodoris, and Eolis papillosa are from preparations kindly lent me by Mr. Brady, York.

1		1	1	Dentalium, Lamellaria, Murex, Purpura, Nassa, Buccinum, Fusus.
3		1	3	Calyptræidæ, Paludinidæ, Litorinidæ, Aporrhais, Natica, Velutina, Trichotropis, Cyprea, Ovula, Cyclostoma.
3		0	3	Acmæa.
1		0	1	Mangelia, Philine (Cylichna?), Bulla, Goniodoris.
∞		0	∞	Scalaria, Doris.
0		1	0	Eolis.
∞		1	∞	Many of the section In-operculata.
5	1	1	1	5 Chiton.
3	3	0	3	3 Patella.
∞	5	1	5	∞ Fissurella, Haliotis, Trochus.
∞	6	1	6	∞ Trochus (Margarita) helicinus.
∞	4	1	4	∞ Emarginula.
∞	3	1	3	∞ Neritina.

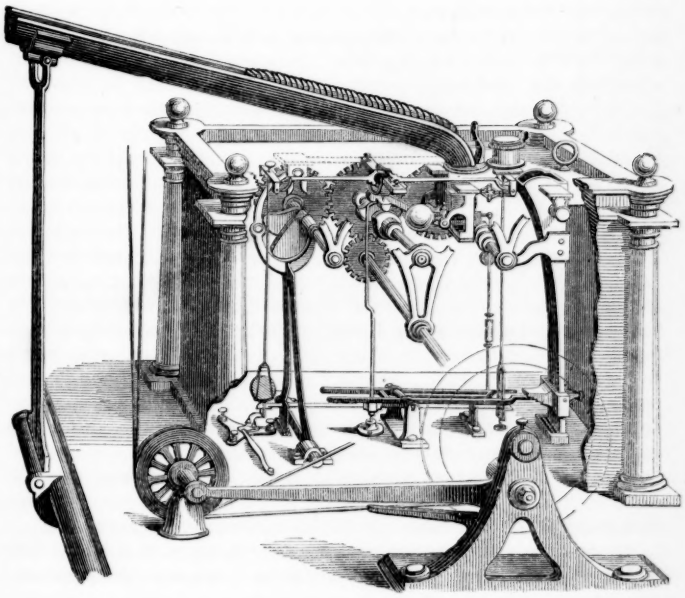
AUTOMATIC WEIGHING OF GOLD AND SILVER PLANCHETS AT THE ROYAL MINT.

BY JOSEPH NEWTON..

(*With an Illustration.*)

THE marvellous progress which has been made in mechanical science in this country during the last half century is nowhere more practically demonstrated than in the new weighing-room of the Royal Mint. That handsomely-appointed apartment of the money-making establishment contains twelve small machines, each one the counterpart of its neighbour, and which, for delicacy of finish and beauty of minute constructive detail, may be said to equal, if not to excel, any mechanical apparatus owing its existence to the conception and the fingers of man. They appear, indeed, when in motion to be gifted with intelligence, and they certainly constitute the nearest approach to thinking machines that have as yet been contrived.

The task of the automatic weighing machines of the Mint, is, to receive each individual planchet or disc of the precious metal produced by the laminating mills and cutting-out presses, and to answer the question as to whether or not those planchets are of the legal weight, which qualifies them for conversion into current coins of the realm. This highly important duty the automatons perform with a degree of speed, regularity, and accuracy impossible of achievement by direct human agency. No matter what the extent of skill, care, and aptitude the mani-



THE AUTOMATIC WEIGHING BALANCE AS USED AT THE ROYAL MINT.

pulator might bring to the work, he could not—as has been over and over again proved—weigh planchets of gold or silver to the extreme nicety which the Mint machines have been made to reach. Through their media the infallible and beautiful law of gravitation is enlisted into the service of her Majesty's coiners, and the results obtained thereby are as unfailingly constant and exact as is the action of that law.

Before proceeding to describe more closely the principle and the peculiarities of construction of the automatic balances, it may not be improper to offer a few remarks upon the great importance to the Mint and to the community at large, of the accurate weighing, or "sizing," as the ancient term stands, of pieces of gold or silver intended for transformation into the circulating medium. From the very earliest period in the annals of minting, its consequence and value have been recognized. Even before coins were in use at all in the British islands, and when slips or cuttings of the precious metals represented money, the sizing of those slips was necessarily attended to, and that with as much care and exactitude as the rude appliances of the time admitted. It was usual at that remote era—which was immediately preceded by the age of barter—for the inhabitants of Britain to go to market, or out shopping, laden with sufficient metal for effecting their intended purchases, and to carry with them instruments for dividing, and scales and weights for weighing it. This primitive process was found to be inconvenient, uncertain, and very troublesome, and soon the expedient was resorted to of having pieces of metal cut and weighed before going out marketing. These clippings were at once the prototypes of, and the substitutes for, coins.

At length, and owing to frauds practised by buyers and sellers, both in respect of the weighing, and the debasement of the metallic symbols, it became necessary to interpose the authority of the law, and thus to regulate and systematize the rude and unshapely currency. Then appeared stamps or impressions, emblems of that authority, and guarantees of the weight and fineness of the metallic dumps upon which they were imprinted. To these marks of genuineness were subsequently added the names of the authorized moneyers by whom they were struck or stamped. The next step in the march of improvement was to decorate—as well as the artists of the day could accomplish that operation—the pieces of metal with representations of the monarch, prince, or prelate under whose sanction they were issued. Dates, legends, and inscriptions followed in process of time, but, as has been shown, the accurate sizing or weighing of the metals was always a subject of grave consideration.

Without pushing historical research further into the misty atmosphere of the far-off past, it may be stated that every Act of Parliament since the Parliamentary institution itself came into being, and every Royal Proclamation passed and promulgated in England, for the purpose of legalizing coins of the realm, has defined with great precision, though sometimes rather verbosely, the standard weight, and the standard degree of fineness, of each denomination of such coins. The law makers and the monarch of the kingdom have, however, invariably recognized the impossibility of producing coins in large quantities of the precise legal standards of weight and of fineness. A certain variation above and below those standards has always been permitted, and this specifically as a "remedy" for imperfection of workmanship. All Acts of Parliament and other legal documents having reference to the manufacture of money, are explicit as to the limits of this remedy. The gradual improvements effected from time to time in minting machinery and appliances, and increasing chemical knowledge, have allowed of the periodical reduction of the remedy, and it would no doubt be curious to trace out and note the changes and modifications which have at various epochs been effected in this direction. At present such is not the purpose we have in view, interesting and instructive as the results of such a search might prove. It must suffice, therefore, to say that, notwithstanding all the mechanical and other advantages which the existing Royal Mint possesses over mints of the olden time, it has not been able to dispense with a "remedy" for imperfection of workmanship.

The varying density of the metals used in the manufacture of coins is one substantial reason why perfect uniformity in the weight of individual pieces cannot be obtained. The machinery of that establishment is throughout excellent, and millions of planchets of gold and of silver are continually being yielded by it, which, if measured individually by means of the finest micrometer gauge, would not exhibit the most infinitesimal difference of size. Placed in a delicately-poised balance, they would, on the contrary, display material differences; some would be found above, and others below, the strictly legal and true standard weight.

Absolute uniformity of weight among coins is a "Will-o'-the wisp," which no one who understands anything of the art of coining would think of pursuing. The mere clasping of a disc of gold between the thumb and finger on a summer's day will alter the weight of that disc, as the test balances of the Mint bear evidence, and changes of temperature will produce a similar result.

It is not essential to examine further into the minute and

almost occult causes which affect the weight of coins; inequalities will exist between planchets of gold and silver though cut mathematically of the same dimensions, and all that can be done is to minimize the variations. Probably this object has been accomplished more completely in the British Mint than in any other mint in the world, and the legal "remedy" for imperfect manipulation is smaller there than in any other existing money manufactory.

The standard of fineness is a point to which reference has been made, and upon which it may be well to add a few further observations. A parallel difficulty exists in obtaining uniformity in this direction. Standard gold should contain twenty-two parts of fine gold and two parts of alloy. The mixture is made at the Mint with scrupulous care; but, in spite of this, the assayer on testing the resulting planchets will find diversity of quality. The law allows and legalizes this diversity, to a very limited extent it is true, but it does allow it. Sovereigns and half sovereigns issued from the Tower Hill establishment are sought after and used by the jewellers of all nations in the manufacture of trinkets, for they are aware that there is more certainty of those pieces of money being very near to standard than there is of the gold coins of any other country. Hence they know precisely how much alloy to add to molten coins, in order to reduce the mass to the low standard of jeweller's gold. Thus, in both a mechanical and chemical sense, it may be fairly asserted that the Royal Mint is in advance of all other mints.

It is to its mechanical excellence that we desire more especially to attract the attention of our readers; and, as we commenced by observing, this is nowhere more convincingly illustrated than in the fitments of the weighing-room. The weighing balances reject all planchets which are "out of remedy," that is, all which are above or below the lines of variation drawn by legal enactment, and they accept for coinage all that are within those lines. Before advancing to the description of their mode of action in achieving this desideratum, we shall introduce in a tabulated form the standard weight, the legal maximum weight, the legal minimum weight, the "remedy," and the dimensions of every denomination of coin circulating in Great Britain and the principal colonies. Such a table, which is given in the following page, will, it is hoped, be of practical value, as it will certainly conduce to a clearer conception of the ingeniously constructed automaton balances, and of the nature of their almost judicial offices:—

Tabular View of Weights and Dimensions of British Coins.

GOLD COINS.

Denomination of Coin.	Standard weight.	Legal max. weight.	Legal min. weight.	Legal 'remedy.'	Diam. of coin.	Thickness of coin.
	grs. pts.	grs. pts.	grs. pts.	grs. pts.	inches.	inches.
Sovereign	123·274	123·531	123·017	0·256	0·875	0·0476
Half-sovereign	61·637	61·765	61·508	0·128	0 755	0·0312

SILVER COINS.*

Denomination of Coin.	Standard weight.	Legal max. weight.	Legal min. weight.	Legal 'remedy.'	Diam. of coin.	Thickness of coin.
	grs. pts.	grs. pts.	grs. pts.	grs. pts.	inches.	inches.
Florin	174·545	175·272	173·818	0·727	1·166	0·0625
Shilling	87·272	87·636	86·909	0·363	0·916	0·0500
Sixpence	43·636	43·818	43·454	0·181	0·755	0·0370
Threepence	21·818	21·909	21·727	0 090	0·666	0·0270
Twopence (Maundy)	14·545	14·606	14·484	0 060	0·546	0·0230
Penny („)	7·272	7·303	7·242	0·030	0·422	0·0202

BRONZE COINS.

Denomination of Coin.	Standard weight.	Legal max. weight.	Legal min. weight.	Legal 'remedy.'	Diam. of coin.	Thickness of coin.
	grs. pts.	grs. pts.	grs. pts.	grs. pts.	inches.	inches.
Penny	145·833	148·749	142·916	2·916	1·200	0 0555
Halfpenny	87·500	89·250	85·750	1·750	1·000	0·0512
Farthing	43·750	44·626	42·675	0·075	0·800	0·0384

To the foregoing tables, which deal with the whole of the coinage of Great Britain as at present issued from the Mint, it may not be improper to append similar particulars in reference to the copper coins, which are fast disappearing from circulation. A comparison between the new bronze and the old copper pieces of money, of which such a course permits, the institution will exhibit palpably the economy of metal in the constitution of the former :—

OLD COPPER COINAGE.

Denomination of Coin.	Standard weight.	Legal max. weight.	Legal min. weight.	Legal 'remedy.'	Diam. of coin.	Thickness of coin.
	grs. pts.	grs. pts.	grs. pts.	grs. pts.	inches.	inches.
Penny	291·666	298·958	284·375	7·291	1·333	0·0937
Halfpenny	145·0 3	149·479	142·187	3·645	1·104	0 0731
Farthing	72·916	74·739	71·093	1·822	0·875	0·0555

* Crowns, half-crowns, and groats, are omitted from this list, because none have been struck at the Mint for many years past, and they may therefore be deemed obsolete.

It will be observed that the legal remedy allowed upon gold coins is very small, that that upon silver coins is somewhat larger, whilst the legal remedy upon bronze and copper money permits a rather wide range above and below the actual standard. The rule at the Mint, however, in each case, is to divide the actual differences as nearly equally as possible between the two extremes. The result is that, on large quantities of coin, a theoretical standard is attained. Silver and bronze coins are merely tokens of value, and individual variations between the particular coins of each respective denomination are of comparatively little consequence. With regard to gold the matter is differently based. The sovereign and the half-sovereign are intrinsically and nominally of the same respective value that their names imply, and they cease to become legal tenders when by abrasion they fall below a certain weight. The weight at which the sovereign may be refused by the Bank of England is grs. 122·500 pts. Thus the allowance for the wear and tear of circulation below the minimum weight of grs. 123·017 pts. at which it may have been issued from the Mint is ·517, or little more than half a grain. The lowest point of weight at which a half-sovereign ceases to be a legal tender is grs. 61·255 pts., its minimum weight at the Mint having been, as shown above, grs. 61·508 pts. It is not often that the Bank or any individual is so scrupulously exact as to draw the line of demarcation at the precise points indicated, though the law would justify such a proceeding.

Having thus endeavoured to explain the origin and to demonstrate the importance of the weighing operation in the art of coining, we may proceed further to state that, prior to the year 1851, the whole of the gold and silver planchets produced at the Royal Mint were weighed by workmen employed there, and known as "sizers." These occupied a large room in the establishment, from which currents of air which might disturb their balances were carefully excluded, and they were each supplied with a tiny pair of scales and weights, resembling somewhat those used by the chemist and druggist in the dispensation of their "medicinal gums." To each sizer was apportioned a certain quantity of planchets, and he became the arbiter of their destiny. The "too heavy" pieces were thrown on one side, to be reduced in some cases by filing, and then re-weighed, and the "too light" pieces on the other side, for relegation to the melting-house. The medium planchets were passed into a receptacle placed near at hand to catch them. Constant practice induced among the sizers a certain amount of accuracy in their operations. But, towards the close of a day's work it not unfrequently happened that their eyes and fingers grew tired of watching and moving, and a reckless admixture

of "too heavy," "too light," and "medium" planchets was the consequence.

In 1851 the knell of this imperfect system of weighing was sounded. The Company of Moneyers, who had long enjoyed the profitable privilege of coining the moneys of the realm, and who traced the existence of predecessors filling similar posts back to the days of the Heptarchy—fell, under the pressure of a Royal Commission, and were pensioned off. The Mint thus came entirely into the hands of the Government. Sir John Herschel was appointed Master, and Captain Harness, R.E. (now Colonel, C.B.), Deputy Master of the Mint, and the last-named gentleman employed himself energetically and skilfully in re-organizing the establishment on a new footing. Two clerks and two mechanics were appointed to succeed in the performance of the duties, though, unfortunately for themselves, not to anything resembling the emoluments of the Moneyers, and in November, 1851, the first coinage of gold under the Government *régime* commenced. Several millions of sovereigns were struck by the following Christmas, and very soon the new Moneyers, as they may be termed, became masters of their work. Captain Harness was not long in discovering the fallibility of the mode of sizing which had been for many centuries before pursued; and, as Mr. Cotton, of the Bank of England, aided by the mechanical genius of Mr. James Napier, had already devised and patented an automaton balance for the detection and rejection of light gold, the Captain determined, if possible, to make the apparatus available for minting purposes, and thus to supersede the time-honoured, but very inadequate and unsatisfactory practice of hand-weighing. Mr. Napier was consulted, and that eminent mechanist was not long in realizing the aspirations of Captain Harness. In a few months several automaton balances were prepared for the Mint. It was essential that these should be so constructed as that they should be capable of separating the light and heavy planchets from those which were of the medium weight, and it will be at once understood, therefore, that this exigency demanded further complexity in the machines than was apparent in the Bank automatons. The Bank had no objection to too heavy coins; their dislike was simply confined to those which were too light, and their machines had only to reject such as "when weighed in the balance" were "found wanting." Mr. Napier solved the more difficult problem in the manufacture of the automatons for the Royal Mint. Experiments in his own factory in the first instance enabled him to do this, and when the machines were transferred to the Mint, they were accordingly found to perform their onerous and delicate functions with unerring exactitude. It became a question of some moment as to what part of the

establishment the new and silent, but most efficient coiners' assistants should occupy on their arrival at Tower Hill. Above all things it was important that they should be undisturbed in their vocation by the tremor or vibration of the powerful steam engines and ponderous machinery engaged in the reduction of bar gold into planchets, or by the heavy and continuous beatings of the coining-presses, which finally converted those planchets into coin. A large room, on the basement story of the Coining Department buildings, and which had been used as a kind of gigantic "what-not," or magazine for the reception of odds and ends of every kind, by the Moneyers, appeared to offer peculiar attractions, and finally the marine stores within it—the accumulations of half-a-century nearly—were displaced and disposed of in order to make way for the incoming tenants. The room was lofty, large, and light; and, singularly enough, it was situated immediately beneath the old sizing-room, the operations of which the automatons were intended to supersede. A short time sufficed to effect a marvellous transformation in the internal aspect of the future weighing-room. Its dingy and dirty walls and ceilings, covered by spiders' webs and honeycombed by age, were cleansed and renovated. A longitudinal trench of considerable depth was dug in it, and this afterwards filled in with concrete and stone, served as a foundation for the weighing balances. So far as isolation of position was concerned, this arrangement was perfect, and a line of low cast-iron tables—rather too low, perhaps, for the convenience of the attendants—was speedily implanted on the solid foundation. These tables, planed on their upper surfaces, which were made to a "dead level," were not long unoccupied. The automatons, in plate-glass and brass frames, soon glistened upon the tables, and, at a first glance, reminded one forcibly of as many skeleton drawing-room clocks arranged for inspection or sale. In order to communicate motion to them, a line of small bright wrought-iron shafting, supported by neat pendants of cast-iron attached to the ceiling, and upon which were hung brass three-motion pulleys, was made to span the length of the room. The shafting was immediately and high above the line of machines, and fine gut bands, passing over its pulleys, descended to corresponding pulleys on the main driving spindles of the automatons. The lower series of pulleys were immediately outside the machine cases through holes in which the spindles ran, and a small brass weight, lever, and friction wheels were so attached as to tighten the bands sufficiently to give constant motion to the coin-feeding slides, etc., of the tiny contrivances within. A series of thumb-screws were added, for the application of pressure great enough to stop the action of

each machine at a moment's notice. The withdrawal of the pressure permitted them to resume their duties at the same brief notice.

In a remote corner of the room was placed the direct, though in itself secondary, motive power—a small atmospheric engine. This was constructed so as to resemble very closely a high-pressure steam engine. It had cylinder, piston, slides, fly-wheel, and governor. Beneath the cylinder, and forming its bed-plate indeed, was a vacuum-chamber of considerable dimensions. This could be exhausted by an air-pump, with which a two-inch pipe connected it; whilst the extent of rarefaction within it was made controllable by means of a steelyard relief-valve, and a barometer-gauge placed on the exhaust-pipe. The air pump was the same which gave motion to the pneumatic apparatus of the coining-presses. It was on the double-acting principle—that is, it exhausted in both up and down strokes, and had many peculiarities to distinguish it from ordinary air-pumps. The writer may fairly take some credit for its invention and introduction to the Royal Mint. Returning to the atmospheric motor of the automatom weighing balances, it must be further said that when its vacuum-chamber was exhausted, and the opening of a cock in the exhaust-pipe caused it instantaneously to be so, it was only necessary further to move the fly-wheel slightly (so as to turn the crank of the engine past the centre) in order to put it in motion. A stream of air from the room rushed immediately through a small brass tube, having a trumpet-mouth, into the cylinder, and acted upon the piston, as steam from the boiler in an ordinary engine would act. Fastened to the arms of the fly-wheel was a pulley, and a strap from this passing round a similar pulley gave motion to the overhead shaft.

We have gone thus minutely into a description of the propelling arrangements of the weighing balances, because they are unique, and they combine perfect isolation with perfect regularity of motion. The varying speed of the general machinery of the establishment cannot affect that of the atmospheric engine and the shafting it drives, because a uniform vacuum is preserved in the vacuum-chamber of the former, and the air exerts a constant pressure on its piston. This uniformity is a *sine qua non* for correct weighing. As the mind of a judge in a court of justice must, if his decisions are to be just, be unswayed by passion or prejudice, so must the mute judges of the Mint planchets of gold or silver be undisturbed in their action, if their sentences are to be truthful and worthy confirmation. We have said that the law of gravitation is infallible; it is so, but it must be allowed fair play and perfect freedom to ensure infallibility. In the Mint balances it is the ruling power, but

that power must not be tampered with. Balances must not be hurried in their movements. It is said that those who think twice before they speak once, will speak twice the better for it; but certainly the balance which is allowed due time for acting will yield far more truthful results than that which is not. One of the great principles of the automaton, therefore, is deliberation, the other, regularity of motion. Let us now proceed to show how mechanical arrangements give practical force to both principles.

We will imagine that a large number—say 10,000 ounces weight, for example—of sovereign planchets have reached the weighing-room. They are first weighed in bulk, because it is necessary that a check should exist upon the few workpeople who are to be entrusted with the task of feeding the automatons, and then commences their distribution among the machines, each of which is supplied with a brass spout, twenty inches long, and placed at an angle. In these spouts roleaux of planchets are carefully deposited, the lowest planchet in each case resting on the top of the machine, and the others supported in regular order, planchet upon planchet, above it. Now, therefore, all is ready for action, and the automatons simply require that a small coupling upon each of their main spindles shall, by the pressure of the thumb and finger of an attendant, be made to revolve with the loose pulleys upon them. Possibly it may simplify and render more intelligible our description if we single out one balance for illustration; and here it may be also said that the whole theory of the automatic weighing machines depends upon the fact that the centre of gravity and the centre of action of its beam are in one line, or on one level. Either centre being disturbed, the balance will be no longer equal. The beam, which is of well-tempered steel, is 8·90 inches in length, and weighs 288·41 Troy grains. Its knife edges find their own resting-places upon curved loops of steel beneath them, and as the points of contact are small, the friction is minimized. The beam is supported immediately below the feeding-spout or hopper, and is preserved from dust by being covered with a brass plate. Above the upper part of one end of the beam—that immediately in advance of the foot of the hopper—is seen a flat disc of polished steel, slightly larger in diameter than a sovereign planchet. This is in fact the scale-pan, and it forms the upper part of a fine steel rod, delicately poised, and readily moved by, or moving the beam. Above the opposite end of the beam depends another steel rod, and this, finishing with a cage at the base of the machine, carries a glass counterpoise of the minimum legal weight of a sovereign. Below the cage, but not attached to it, is a "stirrup," in which rests a piece of platinum wire of the

precise weight of the legal difference or remedy allowed between sovereigns as a compensation for imperfection of workmanship—namely, the 514th part of a grain. Supposing, now, the machine to be started, the first action is that caused by a cam attached to the main spindle, and it consists in a small slide, slightly thinner than a sovereign, being pushed below the hopper, and forcing forward a planchet to the scale-pan or disc. There it rests for about three seconds, and its exact weight is, during the brief interval, noted by the automaton. If that weight exceeds the legal maximum, it depresses the end of the beam upon which it rests, and, as a consequence, raises the opposite end with its stirrup and remedy wire. The planchet is thus proved to be too heavy, and as a flattened tube vibrates below, it is pushed into this by its successor on the scale-pan—another planchet. The lower orifice of the tube passes in its vibrations over the spaces, or slots, and these lead into three compartments, known as "light," "medium," and "heavy" boxes. At the instant the too heavy planchet was dismissed into the tube, the lower mouth of the latter was held by a mechanical finger, governed by the movement of the beam, over the inner or too heavy box, and into this the rejected claimant for sovereignty falls. The next planchet may be imagined to err on the other side of the standard, and to be too light. In this case the beam will be raised by the glass counterpoise, and the tube, by the agency referred to, will conduct the condemned piece of gold into the too light box. When a medium or acceptable planchet arrives on the scale-pan, the beam will maintain a rigid equilibrium, and the succeeding planchet will push it into the tube, which having its mouth held over the central or medium slot, will conduct the accepted suitor into the medium box. In this way the automaton judges try and acquit or pass sentence of condemnation upon all the planchets submitted to their notice. They are thus constituted mute arbiters of the other mechanical operations of the Mint, and they take care at once of the public and the Mint's interests. It is not possible, so long as their intervention is secured, for light sovereigns to pass into circulation, nor for the Master of the Mint to waste the precious material of which they are composed, by issuing heavy ones. The automatons hit the happy medium, and "hold the balance fairly" between manufacturer and consumer. Parsimony and excessive liberality are alike unknown to them; they are just, but not o'er generous.

Finally, it may be observed of the system of automatic weighing at the Mint, that it is as near perfection as possible. It is also economical in the highest degree; for though each machine employed cost a fraction over £200, they have—to use

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Part of the Ruins of Mendoza, destroyed by the Earthquake of March 20, 1861.

a common expression well understood—paid for themselves over and over again in the saving of wages and of gold effected by their use. The maximum number of planchets which the automatons can satisfactorily "dispose of" in a day amounts to 200,000, and the average per cent. of rejected may be set down at five. At the close of each day the whole proceeds are weighed up in bulk—the good planchets being afterwards forwarded for stamping, and the bad returned to the crucible for re-melting. An attempt has been made to save some of the "too heavy," as brands from the burning, by filing and scraping their edges in a noisy machine; but the value of the process is questionable. If their *surfaces* could be touched in a discriminating way by means of a file, or cutter, the case might be different. As it is, the coins are likely to suffer artistically by the use of the scraper, and this is an undue price to be paid for a problematical advantage. We give at p. 73 an illustration representing one of the Automaton Balances of the Mint, the artist having removed a portion of the "case" so that the "works" may be the better seen.

THE EARTHQUAKE AT MENDOZA, 20TH MARCH, 1861.

BY WM. BOLLAERT.

(*With a Tinted Plate.*)

I AM indebted to my friend Major Rickard,* who visited Mendoza in May, 1862, for the admirable photographic view of the devastation occasioned by the dreadful earthquake which occurred on the 20th March, 1861, and which is excellently shown in the annexed plate, and also for a remarkable letter written by Don Domingo de Oro, a gentleman who was buried for five hours beneath the ruins of the city, and containing many interesting and hitherto unpublished facts. I have translated this letter from the original Spanish, believing that it would be acceptable to English readers; but before introducing Don Domingo's terrible recital, I will offer a few remarks relative to the city and province of Mendoza, and make the narrative more complete by citations from other letters written from the scene of the disaster.

Mendoza is situated in 32° 52′ S. lat., 69° 6′ W. long., 4891 feet above the level of the sea, and at the eastern foot of the

* See *A Mining Journey across the Great Andes*, with Explorations in the Silver Mining Districts of San Juan and Mendoza, by Major F. J. Rickard, F.G.S., etc. etc.—*Smith, Elder, & Co.*, 1863.

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Great Andes. It is shut out from any view of the Cordillera by a range of lower mountains which intervene. The appearance of the city before the earthquake was neat and cheerful, the houses of one story, with porticoes, mostly built of *adobes*, a sun-dried brick, plastered and whitewashed, and the streets laid out at right angles. Its *Alameda* or public walk was equal to anything of the kind in South America, being nearly a mile in length, nicely kept, and shaded by rows of magnificent poplars, or *alamos*, from which its name.

The climate is delightful and salubrious, although *goitre* affects a few. The population of the city before its destruction was some 16,000 souls, about one-third of that of the whole province. The Province of Mendoza occupies a space of 150 miles N. and S., along the eastern side of the Cordillera of the Andes, and about as much E. and W. It produces wine, brandy, raisins, figs, wheat, flour, hides, tallow, soap, etc. Of its mines, those of silver at Uspallata are important; and among its mineral products are reckoned, copper, limestone, gypsum, alum, mineral pitch, bituminous shales, coal (probably tertiary), slates, fire-clays, saline deposits, including, it is said, nitrate and sulphate of soda, and indications of borax.

In the Andean region of this province, in a N.W. direction from Mendoza, is the volcano of Aconcagua, more than 23,000 feet above the sea; that of Tupungato, to the S.W.; that of Maipu, to S.S.W. (15,000 feet); and that of Peteroa, S. of the Maipu.

Having thus made the reader acquainted with the locality, I will leave the following extracts from letters to tell the story of the disaster:—

"MENDOZA, *March 22nd,* 1861.

"This city was visited by an awful earthquake, at 8·45 P.M. the evening of the 20th inst. In seven or eight seconds the whole city and habitations in the vicinity were in ruins, beneath which disappeared about two-thirds of the population, say 12,000. I assisted to save Don F. Garfia, who had been *ten* hours buried under ruins, two yards in depth."

Another person writes on same date:—"I have only lost two of my children and the nurse. My wife and the rest of the family were buried for a time, but we got them out, they are much hurt."

On the 24th, another letter says:—"At 8·45 P.M., the Teremoto or severe earthquake took place. In a moment, three-fourths of the city was in ruins; the greater portion of the inhabitants are victims. The 21st, 22nd, and 23rd, the shocks continued at intervals, when the remainder of the houses fell. The few inhabitants left alive are doing their best to search for and rescue the buried ones.

"The earthquake movement came from south and east, and was impelled to north and west; these movements continuing about five or six seconds. This once smiling city is now level with the plain. Although I was wounded by the falling of a wall, I exerted myself in the hope of assisting others. I heard groans and calling for help from beneath me at every step. Some, who appeared to have lost their senses, screamed for their fathers, mothers, brothers, sisters, wives, husbands, children and friends. Men, women, and children were dragging at the robes of a priest, praying for absolution. I saw heaps of mutilated fellow-creatures, I heard their dying and despairing groans.

"In a few days I fear the few who have been spared will become victims to the knife of the assassin-robbers. Putrefaction of the dead bodies has commenced, and we have but little food.

"Just after the great shock, I went to the public walk, where I beheld a group praying round a monk, who instead of comforting assured them that flames and burning sulphur would soon consume them, beseeching all to repent and pray. This was not my opinion; I urged the desponding party to be up and doing in aid of those who were buried amongst the ruins. My friends P—— and C—— had been buried alive for an hour, whilst striving to save a child, and, although separated, could converse freely. 'I fear we are lost,' said P——. 'I believe we are,' replied C——. 'Had we not better try to sleep, and so not feel the agonies of death?' 'Perhaps we had better do so. Farewell, farewell! Should you be saved, say to my mother that in my last moments I thought of her. I will do the same for you, if I am preserved. Farewell!' 'Dear friend, I am choking with the dust; more walls are falling on us; I am getting squeezed more and more down to the earth. Let us alternately cry for help. Hark! I hear footsteps above us.' In truth, B—— had arrived, and heard the voice of his son, C——. Digging was commenced; but ere the two friends were got at, C—— had died. Many such scenes occurred throughout the ruins. Our friend Urizar was buried for ten hours. S—— was half an hour below ground; his position was discovered by his dog 'Othello.' Muñoz was saved by falling under his horse. We hear from San Juan (some 50 leagues to the N. of Mendoza) that the town has suffered much; the river there has left its bed, and inundated the city. To the S. and E. the earthquake effects have been less. About a hundred years since Mendoza suffered very considerably from an earthquake, which is known as the Teremoto of Santa Rita."

Seven or eight months before this present earthquake, at a

distance of four or five leagues from Mendoza, there were movements of the land sufficient to displace trees; there were openings in the ground from which came out sulphurous and saline matters. Two nights before the earthquake, at same spot, the ground rose and fell.

The great movements of the earthquake were from S.W. to N.E., and then from N.E. to S.W., the ground opening in many places. It was not preceded by noise or rumbling. The ground seemed to rise or swell up. Twelve miles from the city the ground opened in a S.E. and N.W. direction for more than three miles in length, and in places two and a half *cuadras* (375 yards) wide, and saline waters were thrown out. On the night of the earthquake, shocks occurred at intervals of five or six minutes, up to the sixth day. On the eighth day they were more frequent, then diminished in number again. The shocks were accompanied by sounds like the firing of cannon. Under Mendoza there seems to be a large hollow, and people have an idea that there is much water in it. It is said that a nun was got out alive after eight days' burial, but she died shortly afterwards.

It was reported that a French watchmaker in Buenos Ayres (which is about 550 geographical miles a little S.E. from Mendoza*) observed the pendulum of his clocks much affected at about 9 P.M. on the night of the earthquake.

On the 29th March, 1861, Mr. R. F. Budge, of Valparaiso, communicated to the writer of this paper as follows, on the subject of the Mendoza earthquake: "I noted in my catalogue of earthquakes this one, not from the strength of it here on the 20th inst., at 8.35† P.M., but from its duration, which led me to believe that we should soon hear of a dreadful catastrophe at some distant place in Chile. On the 25th an express arrived from Mendoza, announcing that it had been totally ruined, the great shock having occurred there at 8.45 P.M., lasting less than a minute, which was the time I noted here. Two pendulum clocks, beating N. and S., stopped."

Since March, 1861, occasional shocks have been experienced at Mendoza. In a Buenos Ayrean paper of January, 1863, it is stated that Mendoza was lately visited by rather a severe series of shocks. The new town, rising out of the ruins of 1861, is constructed of wood.

I will now give the translation of a letter of Don Domingo de Oro, which is a very remarkable record of the thoughts and feelings of a man buried alive for more than five hours:—

* Hence it would seem that the undulation took fifteen minutes to travel 550 geographical miles.

† In this instance, 140 geographical miles in ten minutes. In the one case, it travelled along the Pampas of Buenos Ayres; in the other, through the Andes.

"To MAJOR F. I. RICKARD, Inspector-General of Mines, etc., etc.

"BUENOS AYRES, *December* 13, 1862.

"My dear Sir,—In conformity with my promise, I will try to narrate to you my impressions as well as my reflections on the subject of the horrible night of the 20th March, 1861, in Mendoza. I will do my best to give you an account, in the plainest terms possible, of one of the most dreadful occurrences on record.

"It was about a quarter to nine at night. I was at the house of Don Meliton Arroyo, in an apartment near to the street, in company with my relative, Pedro Zavalla. The house was in the 'Calle del Cormercio,' a cuadra and a half (225 varas) from the public promenade. I was standing, and about to proceed for my customary evening walk, when there was heard a loud cracking in the roof of the house. The rumbling sound which generally precedes an earthquake was heard in the city, but not by us; still we felt perfectly satisfied as to the cause of the creaking in the roof of the house, and Zavalla cried out 'Temblor,' or earthquake; 'and a strong one too,' I exclaimed, running towards the door, so as to get into the street; and a few quick steps brought me there, when I passed onwards towards the promenade.

"The upper portion of the house of Arroyo, which was of one story, bulged out and fell to the ground to my left, a little in advance of me. At this moment I lost the hope of being able to arrive at the nearest intersection of the streets, at which point I thought to escape and save my life. At times it happens that one gives utterance to one's thoughts, or we think aloud; so I went onwards, repeating, 'it is impossible to be saved,' when, as if to confirm my words, I received a violent blow from behind, which struck the upper part of my right leg, when I was thrown with my face to the ground, and my arms extended. I felt at the same moment that I was being covered up with weighty earthy matters, and was stretched out on the path. A second afterwards I heard the noise of heavy bodies falling, some of which increased the weight of materials above me. Shortly I heard a terrible and prolonged noise, one of the effects of a severe earthquake shake.

"I had not lost the use of my senses in any way, but the idea rushed upon me that the whole city was in ruins. Although the weight above me was very great, and my face forced down upon the path, I could breathe sufficiently to prevent suffocation. As I felt no acute pain in any part of my body, I thought I was not wounded, and that above me the layer of ruins might not be very thick. I now tried to move my legs

and arms, but this I could not do, for I was part and parcel, as it were, of the solid material in which I was buried. I had no doubt but that my last hour was near at hand.

"I now heard a human voice; it was that of my poor friend Zavalla, beseeching assistance. He had followed me, and had participated in my fate; but he was in a much more lamentable position. I did my best to cry out to him not to waste his breath, except when he heard any one walking above him, and then to make all possible offers to any one who would assist to extricate him from his living tomb. He replied to me; and then I heard him at intervals utter unconnected words, then inarticulate sounds, by which I supposed he must be in the agonies of death, and then followed an eternal silence, as far as my poor friend Zavalla was concerned.

"My reflections now became painful indeed. Subterranean noises were heard, and shakings of the earth were felt. I at times supposed the spot in which I was buried would sink into an abyss, or that the crater of a volcano would burst out there. I knew that in such like earthquakes destructive fires were known to break out, and that there might be one near to me; that the great *acequia*, or watercourse, in the public promenade might be obstructed by ruins, its waters would run over, and so get amongst and under the ruins, in which case I should be drowned within my sepulchre. Admitting that nothing of this occurred, to whom was I to look for help? My friends in Mendoza were few, and some of them, like myself, were doubtless in a similar position; others would have themselves and families to look after; then, in such circumstances would people think of their friends before their relatives? if they did, how were they to divine where I was? If people were looking for me, how was I to make my position known? for although my friend Zavalla had heard my voice, and I had heard his, this was no proof that I should be heard through the now increased mass of ruins that covered me. It seemed that my salvation in this life was impossible, and I resigned myself to the decrees of Providence. Then I wished that the waters would come and drown me, so as to shorten the period of my misery; and I even recollected to have read that miserable slaves had abridged their lives by swallowing their own tongues, and was decided upon attempting it if I found fire or water approach me, as this was the only means at my disposal.

"Although it was afterwards discovered that I had a broken bone, and many wounds, I did not suffer any bodily pain, excepting from the weight of stuff above me, heat, and insufficient respiration. I was indeed very sad, but not dejected, and I prepared myself to separate from life without becoming desperate. The thought that made me most miserable was the

probability I should die of starvation, when my life of agony would be prolonged.

"Thus passed two long, long hours. Hope indeed fought with my drooping spirit. I am neither devout, nor am I impious. I did not turn to God and beg for a life that appeared to me to be quite out of the order of nature to grant, but I did submit myself to his decrees; and considering myself as a mortal who was going in robust life to the gates of eternity, I did all I could to calmly contemplate my frightful situation, which I may call that of a living corpse.

"After a time I heard a conversation between two men; one said, seeing that it was impossible to advance in that direction with a carriage, he would leave it there and take the horses away. In a moment it came to my recollection that on the previous day I had been taken in a hired vehicle to a country house in the vicinity of the city, and I believed the voice I heard was that of the same coachman who drove me, which same man had been rather talkative during that ride, and that he had indirectly asked my name, and said he believed that he had seen me in Copiapo.

"I shouted out as well as I could several times, in the hope they would hear me, which they did at last. When they replied, I beseeched them to succour me, telling them that although I was covered by a great weight of ruins, I was unhurt (which I then believed), and that I should not perish if any assistance was afforded me. At once both of them commenced to remove the rubbish that covered me.

"Lately I was so resigned, and when I had no hope of being rescued; now that it seemed I was about to be saved, I felt my spirit sink within me. The companion of the good Gonzales (for that was the name of the coachman) beginning to feel the work severe, or on account of other motives, said that he must leave off, but that he would return. Once gone, I could not believe he would ever come back; I feared Gonzales would follow his example; and as I gave myself only five or six hours more life if the weight above me was not removed, I now considered I was indeed lost. But Gonzales, as if he had divined my thoughts, called aloud, telling me not to despair; that his death alone should prevent him leaving his work of disinterring me undone.

"You know that the houses of Mendoza are built of *adobes*, or sun-dried bricks, and the mortar merely of mud, and not of lime, consequently easier to separate than burnt bricks and mortar; so that when the walls fell down, they did so in such a manner as rather to favour the removal of the ruins, even by the hands alone. My benefactor worked away for more than two hours, when he at last touched my head, and in a few

moments he exclaimed with joy, 'now take breath.' I cannot describe what feelings of gratitude I had for that generous man. He now tried to extricate me, and to put me on my feet.

"My legs were swelled in a monstrous manner and covered with wounds; I could not stand, for one had become shorter than the other. My hands, face, and head were dreadfully bruised.

"Gonzales wished to carry me to the public walk, but this he found impossible to do; so he proposed to transport me from where I was, which spot was full of deep inequalities, caused by his throwing up the ruins to get me out, but this he failed in, for where I lay I was still in peril in consequence of a ruined wall which threatened to fall with the continued earthquake movements of the earth. Gonzales at this juncture did not even know the fate of his own family, and had to leave me.

"There I was alone and unable to move. I took a glance at the scene around; how frightful it was! how horrible! The moon still shone on that huge heap of ruins, a few hours before a city of life and joy. At the distance of five or six yards from me there escaped dying groans from some ruins, which appeared to me to be those of Cesar Solar, his wife and little daughter. Farther off I heard screams and cries which went to the heart, begging for assistance; these were from Teresa Garcia, whom I afterwards saw attending the sick and wounded. Fire had broken out not far from me, and was advancing towards the direction I was laying; but, thanks to kind Providence, I was not unnerved. There were many who were actively engaged in assisting and rescuing their fellow-creatures; but there were others plundering, whatever they could lay hands on, during this awful convulsion of nature. Nicolas Villanueva passed hurriedly by in search of help to assist him to rescue his large family, whom I could hear from under the ruins, recommending themselves to God's mercy, and preparing themselves to die; the fire had now reached some combustible matters, and all around was in a blaze. There now came up to me Señor Arroyo, who told me with broken heart, ejaculating, that he had lost six of his children; still he went searching for his unfortunate friend Zavalla, in which search he rescued a poor maniac woman who was buried near to me.

"But how am I to relate to you all the frightful scenes I saw on that awful night?

"To those who passed, whom I thought able to move me, and would do so for money, I offered gold to carry me to the public promenade, which was only two hundred and fifty yards distant; but no one gave heed to me. Early in the morning Ramon Muñoz, a Chileno political emigrant, mercifully came to my assistance with a party of men, and transported me to the

promenade, where I was placed among dead, dying, and many who were sadly wounded.

"My clothes had been torn to pieces, my hat lost, and the early morn was cold. Luis Marco gave me a dressing-gown, and in this state I remained until the evening, when I was seen by Mr. Bergman, a surveyor, who had lost his wife and all his children except one; he proposed to remove me to a less disagreeable spot, where I found Mr. Civit with a broken foot, others wounded, some ladies who had lost their families; from these I received whatever assistance they could render me. I must not omit to particularize the name of a young Chileno, Señor Vieites.

"Four days I remained with this party in affliction. Up to this period such charity and kindness as could be proffered I received, when Don Tomas Garcia of Mendoza discovered me. We had known each other in Chile, and were friends, without being very intimate. Not only his house in the city, but one in the country, were destroyed on the night of the 20th of March. He had lost three of his children in the earthquake; the remaining three had been saved through the exertions of his beloved wife—he himself most miraculously; he had already built up a hut.

"However, under such appalling domestic affliction, he did not forget the sufferings of others. He had sought for me for three days, although he had been assured that I had perished. He had me borne with the tenderest care to his newly-erected hut. His good wife had prepared for me a tent out of pieces of cloth and carpet, and where I felt that Garcia and his ministering angel of a wife would take care of me.

"Her necessary household affairs were not forgotten; these being finished, she would retire for a while to pray and weep for her lost little ones, then she became a true sister of charity; never can I forget her and all her pious doings. She bathed and dressed my wounds; she gave me medicine to assuage my pains, and helped me to the food I required, with such persuasive gentleness, only to be done by tender-hearted woman; she was the personification of human goodness. I would at times call for a servant to assist me, but ere one could arrive she was at my side, night or day, ready to attend to me.

"Very shortly after the arrival of Dr. Day, Garcia brought him to me; and now the medical man took charge of my cure. Through the unremitting kindness of Garcia and his wife, and that of Dr. Day, after a period of twenty-three days, I could lay myself down; but it was three months ere I could go upon crutches, when I journeyed to San Juan.

"Years had passed that I had not shed a tear; the destruction of the city of Mendoza, and even whilst in the frightful position of being buried alive, no tear dimmed my eye; but the

day of separation from Garcia and his wife came, my heart was now moved. Still I kept a serene look; the moment for saying farewell arrived; I saw them in tears—speak they could not—but ejaculated their prayers for my restoration to health. I now felt most acutely, my heart beat rapidly; I was tongue-tied, but a flood of tears came to my relief. We embraced each other; I covered my face, and was glad indeed when the carriage was announced to convey me to San Juan.

"The spectacle of domestic life, and the love I observed in the family of Garcia, made me a better man; there I saw an example of real felicity only to be obtained by the practice of virtue, and I could not now believe that these were so exceptional as I had formerly considered. Can I ever forget Garcia, his wife, and the coachman Gonzales?

"To conclude: if there were fiends in human form, and who committed the most atrocious acts of rapine during and after the calamitous earthquake, there were also examples of heroism and goodness. A young lady who had been exhumed from the ruins, and only had her under-garment on, the moment she found herself preserved, began to work at once in the liberation of others, continuing it all that very cold night, and so scantily clothed. A poor woman (not a model of virtue) who escaped death most miraculously, and badly wounded, worked incessantly during that night of horrors, and saved at least five fellow-creatures from amongst the ruins. A good man whose habitation was without the city, but was in Mendoza when the earthquake came on, remained all night succouring the distressed, assisting to save many from an untimely grave; proposing to himself that having disinterred the one he was at work at, he would go and look after his own family; which being done, another and another scene of distress met his sight, to which he went. Kind Providence rewarded him, for at day-break when he got to his own house, although he found it in ruins, his family was safe, but weeping for him, supposing that by his not returning during the night that he had been buried in the ruins.

"Your faithful Friend and Servant,
(Signed) "Domingo de Oro."

THE MIDNIGHT SUN.

BY THOMAS W. BURR, F.R.A.S., F.C.S.

THE December number of the INTELLECTUAL OBSERVER contains a notice of a very interesting work, entitled *A Spring and Summer in Lapland,* by an "Old Bushman," which the reviewer introduces by some remarks on the influence over the imagination of those regions of the earth which lie sufficiently near the North Pole to exhibit the remarkable summer phenomenon of an unsetting sun; and proceeds to quote Longfellow's spirited lines, describing the effect on the "Ancient Mariner" who discovered the North Cape, in which lines—

> "And *southward* through the haze,
> He saw the sullen blaze
> Of the red midnight sun,"

we shall presently see there is an astronomical blunder. The book of the "Old Bushman," which is replete with the most interesting information in Natural History, also contains a vivid description of this singular appearance, and these notices have produced a shower of communications to the INTELLECTUAL OBSERVER asking an explanation, "how the sun can be seen at midnight?" Such inquiries are principally, as may be imagined, from the more juvenile readers, and in consequence of their number, the conductors of this journal, with their usual readiness to gratify laudable curiosity, and impart useful information, have requested me to give, as briefly and simply as possible, the reasons of the phenomenon and the explanation of the effects produced, which, it is trusted, will at once clear the path for the younger portion of my readers, and may also not be unacceptable to some "children of a larger growth," whose astronomy has become a little rusty.

The effect in question, it is obvious, involves a consideration of the causes both of the seasons and of the various lengths of day and night, and these are due to two peculiarities of the earth as a planet, viz., the obliquity of the equator and ecliptic, and the parallelism of the earth's axis.

Every one knows that the earth revolves round the sun in the period we call a year, and that it rotates on its axis in the time we call a day, including periods of light and darkness, which, except on two days in the year, are unequal in all parts of the earth except at the equator—the days being long and the nights short in summer, and the days short and nights long in winter, at each particular place. The two periods when the days and nights are equal all over the world, consisting of twelve hours each, are called the equinoxes, and occur about 21st March and 21st September, and were the orbit of the

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earth coincident in level with the position of the sun, or, speaking astronomically, were the equator and ecliptic in the same plane, and were the axis of the earth perpendicular to the orbit, the phenomena of the equinoxes would be those of the whole year, and the temperature of each place, and the length of day and night, would always be those which it has at the dates just given. But neither of these conditions exists, the planes of the equator and ecliptic (or path of the earth round the sun, forming the sun's apparent path in the heavens) are not coincident, but inclined at an angle of 23½ degs., and the axis of the earth is therefore tilted out of the perpendicular to its orbit to the same amount. This axis also in its revolution round the sun is invariably directed to the same point in the heavens, called the Pole, which is easily distinguished by the well-known Pole Star,* and this constant direction of the axis causes an unequal exposure to the light and heat of the sun during different lengths of the day, and the obliquity of the ecliptic also causing the solar rays to fall with very different degrees of verticality on the earth at different times, produce the charming variety of the seasons. To show the importance of these arrangements, let us suppose the axis of the earth had not been inclined to that of its orbit, and mark the consequences. Under this condition every portion of the earth during the year would have the duration of the days and nights equal. The sun's rays, falling perpendicularly, would burn up the regions near the equator, and render them uninhabitable. The countries situated between the equator and high latitudes would have the temperature of a mild spring, which would be continuous, and they would be deprived of the beautiful changes of climate we enjoy; while few, if any, plants would attain maturity, rendering the existence of animals a precarious and doubtful matter. But the condition of the regions at a considerable distance from the equator or near the poles, would be very dismal; an eternal winter and continual desolation would prevail in countries where millions of human beings now live happily. Still worse would be the result of the earth's axis being placed parallel to the ecliptic—sharp alternations of day and night, heat and cold for six months at the time, would be the unpleasant fate of each hemisphere under this state of things.

Happily for us, the axis is inclined, and has the constant direction before mentioned; and to get an idea of the result, let me ask my young friends to take an orange, as an easily obtained miniature of our globe, and passing a long needle or

* The minute variation in this direction, due to precession, is of no consequence as connected with the seasons, and does not interfere with this explanation. See the author's paper on the Precession of the Equinoxes in the INTELLECTUAL OBSERVER of June, 1863.

wire through its flattened poles, carry it steadily round a candle or lamp placed in the centre of a table, taking care to slant the wire about a fourth of the distance from the table to the ceiling, and always keeping the point in the same direction. At one part of the revolution the orange should be lifted a little above the level of the flame, and at the opposite point a little depressed. At the two opposite intermediate points only should the orange and flame be in the same plane. If we now examine the effects of the light upon the orange in its revolution, we shall get an exact representation of the sun's effect upon the earth, and to show this accurately, let us notice particularly four different positions in detail. First, if the orange be in one of the positions level with the flame, it will correspond with the earth in the northern spring, when the sun is exactly at the same distance from both poles, and affects each hemisphere alike—this being about the 21st of March; by the 23rd of June the earth (or orange) will have moved to the point in its orbit most depressed below the level of the sun (or flame), and the north pole is then nearer to the sun than the south, and the northern hemisphere receives a greater amount of heat than is received by the southern—constituting the northern summer. If we note carefully the rays of light falling on the orange, it will be seen that in this position they extend over and beyond the north pole, while the south pole remains altogether unenlightened, so that, notwithstanding the rotation of the earth on its axis, the day will be continuous at and near the north pole, while it will be constant night in the opposite regions of the south.

Proceeding with the illustration we arrive at another of the equinoctial positions, corresponding to the northern autumn, on the 21st of September, when the hemispheres are again equally lighted, and the day and night again equal. Lastly, from the 21st of September to the 21st of December, the earth progresses to her position above the plane of the sun, and the orange will then be above the level of the flame. Here the north pole is turned away from the sun, while the south pole inclines towards it; hence the northern pole and hemisphere receive a much smaller portion of light and heat than the southern, and it is therefore to us winter, while the south is enjoying its summer. It is a singular circumstance, that in consequence of the eccentricity of the earth's orbit, we are really nearer to the sun in our northern winter than in the summer, by about three millions of miles; but this is so small a space in proportion to the whole distance of the earth from the sun, and its consequences are so far outweighed by the more important results of long days and short nights, with greater verticality of rays, that its effect is immaterial.

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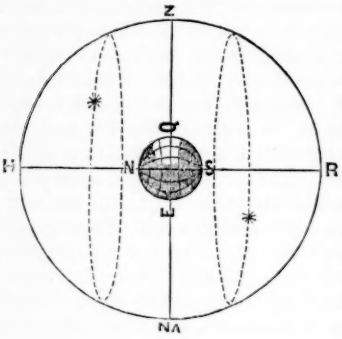
It is, however, necessary, with reference to our especial object of explaining the Midnight Sun, to go into further detail of the unequal days and nights of different latitudes, and as some little difficulty may arise from the apparent motion of the sun in altitude, due to the earth's rising and sinking above his position, it may be desirable first to consider the apparent paths of the stars as caused by the earth's rotation on its axis, these bodies, from their distance, being free from the effect produced upon the sun's meridian altitude by the obliquity of the equator and ecliptic, and therefore not altering their declination or distance north or south from the equator. Some simple diagrams will enable us to do this most effectually. In Fig. 1 the appearance of the heavens, as seen by an inhabitant of the earth at the equator, is indicated. In this and the two following figures the letters of reference are the same, H R being the observer's horizon; N and S the north and south poles of the earth; E Q, its equator; Z and NA, the zenith and nadir of a place. The diagram then shows that a place on the equator will have the poles in its horizon, and that all the celestial bodies will rise and set at right angles to the horizon, and will continue just as long a time above it as they do below. The dotted lines represent the paths of stars or the sun, and as the rotation of the earth on its axis is uniform in rate, the semicircle above will be described in the same time as the one below, and this being twelve hours each, the days and nights will be equal throughout the year. The observer will also see the whole of the stars in the heavens, which he can do nowhere else, although some will be in very unfavourable positions. Passing to Fig. 2, a very different state of things is presented to view. Here the north pole is in the zenith, and the equator (or equinoctial, as the circle in the heavens answering to the



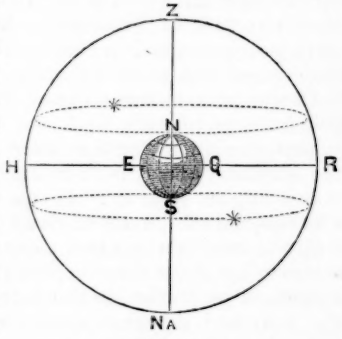


Fig. 2.

earth's equator, is termed) forms the horizon. The heavenly bodies, such as those stars which are visible at all, never rise or set, but may be observed during the whole of their apparent revolution, caused by the real rotation of the earth on its axis, their distance from the horizon never varying, and their motion being in circles parallel to the horizon. Stars below the equator, that is, all the stars of the southern half of the celestial vault, are never visible, while those in the northern half never disappear. The sun, for six months in the year, when his position is below the equator, or he has south declination, never rises above the horizon; while during the other six months, having north declination, he never sets, but moves round in a series of circles nearly parallel to the horizon, or, strictly speaking, in a spiral, first ascending, till on the longest day he attains an altitude of $23\frac{1}{2}$ degs.; and then descending, till lost to view about the 21st of September. If the observer depart from either the pole or the equator, in the first case the pole will sink from its position over his head; and in the latter, the pole towards which he is travelling will rise. Wherever he may stop, the pole will be the same number of degrees above the horizon as the observer must use to express his latitude. To illustrate such a position Fig. 3 is drawn. The diagram represents the north pole elevated 60 degs. above the horizon, showing that to be the northern latitude of the place, and here, or indeed at any other latitude, except 0 degs. and 90 degs., all the heavenly bodies rise and set obliquely, their diurnal paths making with the horizon angles equal to the co-latitude, that is, the difference between the latitude and 90 degs.; in this case the co-latitude equals 30 degs.

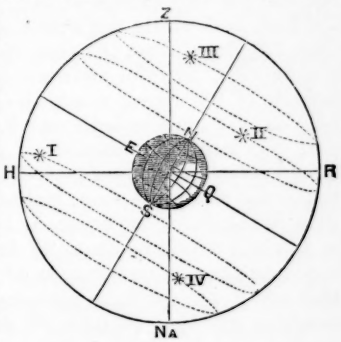


Fig. 3.

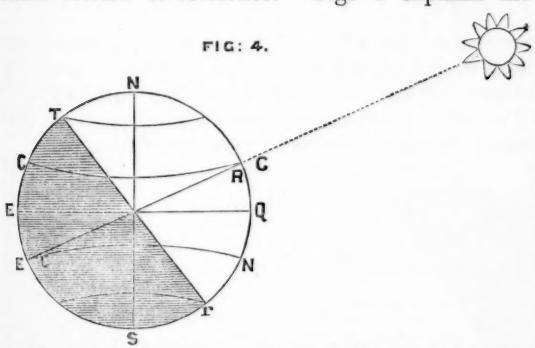
A heavenly body on the equator will have its diurnal path half above and half below the horizon, and if the body so situated be the sun, the days and nights will be equal to that place. Those bodies to the south of the equator will, in the latitude of the figure, have the greater part of their diurnal path below the horizon, and the smaller part above, as shown at I; on the contrary, those to the north of the equator have the greater part of their daily path above the horizon, and the smaller below, as at II. Now the sun varies his distance from the equator, ranging about $23\frac{1}{2}$ degs. on either side of it. When

north of the equator the days will be more than twelve hours long, to an observer at 60 degs. north latitude; and when south of that circle they will be less than twelve hours. There is a circle, III, representing the path of a star which never descends below the horizon. Thus, at London, there are certain constellations, such as the Great Bear, Draco, Cassiopea, Cepheus, the Little Bear, Perseus, and others, which never set, and which are visible on every fine night throughout the year, performing their incessant revolutions round the north Pole Star as a centre. Such stars are called circumpolar, and all stars whose distance from the pole is less than the latitude of the place will be circumpolar there. Of such stars at London, Capella and those of the Great Bear form conspicuous examples, being always above the horizon, though of course requiring instrumental aid to be seen in that part of their diurnal path which is performed in daylight. Within the same distance from the depressed southern pole, will be found a number of constellations, the stars of which never rise to our observer at 60 degs. north latitude; an example is seen in the figure at IV, and many of the southern constellations are so situated with respect to us. I have been thus minute in describing the apparent paths of stars at different latitudes, because the explanation of the Midnight Sun depends upon the fact, that within the Arctic circle, that is, at a less distance than 23½ degs. from the pole, the sun becomes at midsummer circumpolar, like the stars we have so called, and while at a latitude of 66½ degs., where the circle is drawn, this happens only on the longest day; as we proceed nearer to the pole, his path becomes more parallel to the horizon, and he continues circumpolar for a longer period. The sun, in fact, seems to go round the earth in a ring, inclined to the horizon, having his greatest altitude, due south, at twelve o'clock in the day (which in Lapland would be about 47 degs.), and his lowest point just touching the northern horizon at twelve o'clock at night. Further north, the southern altitude would become less, and the northern greater; till near the pole the circle would be nearly parallel with the horizon, and could we reach the pole, entirely so. Thus, the "Old Bushman," whose quarters were at Quickiock, only just within the circle, although for about a month at midsummer he could always see the rays of the sun reflected on the northerly fells at midnight, and, in fact, for two months had the night as light as day, for reading, hunting, and shooting—had to ascend "Porti Fellen," about 5000 feet high, on June 24th, at midnight, to see the sun himself; but had he gone further north, even to the North Cape, as many travellers do, no ascent would have been necessary. It may here be remarked that Lapland is the only place which is

readily accessible by Europeans desirous of witnessing the glorious spectacle of the unsetting sun. It is also a most interesting country on other accounts. Despite its northern position, corn still grows in latitudes which elsewhere are sterile, for which it is indebted to the Gulf Stream impinging on the coast of Norway; while the luxuriance of its flora, during the short but brilliant summer, and the profusion of animal life peopling the magnificent scenery, render it well worthy a visit, and a trip to Norway is now becoming comparatively frequent. To all such intending tourists a perusal of the *Spring and Summer in Lapland* will be most essential, containing, as it does, full information for reaching either Hammerfest, near the North Cape, or Happaranda, at the head of the Gulf of Bothnia, in the best manner; while in a natural history point of view the book is invaluable.

To illustrate still more clearly the effect of increased latitude in producing continuous daylight, it will be desirable to introduce a few more diagrams. Figs. 4, 5, and 6 have the same letters of reference. Fig. 4 explains the long days and short nights of the northern summer (the sun about the 21st of June being over the Tropic of Cancer, and therefore at its greatest northern declination), and, at the same time, the short days and long nights of corresponding southern latitudes. N S is the axis of the earth; E Q, the equator; E C, the ecliptic; C R and C N, the Tropics of Cancer and Capricorn; and T R, the line separating light and darkness, or the real horizon. At the central line of the globe, on the side turned towards the sun, it is mid-day; at the terminator, or line of shading, it is, on one side of the globe, sunrise; and on the other, sunset; while on the central line of the side in shade, it is midnight. At N, and the adjacent parts down to the Arctic circle, no portion of the globe will be carried by the diurnal rotation into darkness, and there is, therefore, continual daylight. At the Tropic of Cancer places are carried through unequal portions of the light and shaded parts, and there are long days and short nights.

FIG: 4.



At the equator the light and shaded parts are of equal extent, and the days and nights are equal, as is always the case there. At the Tropic of Capricorn, the light and shaded portions are unequal, but inversely to the Tropic of Cancer, and there are short days and long nights. At S, and adjacent to it, so far as the Antarctic circle, the earth's rotation produces no emergence out of the shaded part, and the night is therefore continuous.

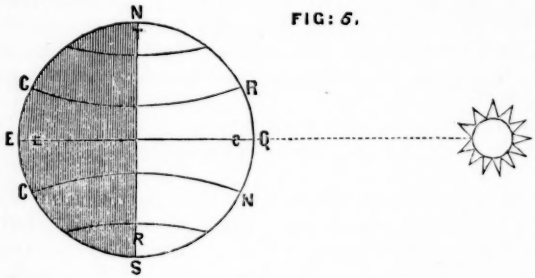


FIG: 5.

Fig. 5 represents the effect of the sun being over the equator, as he is in March and September, instead of over the Tropic of Cancer; the days and nights are then equal all over the world—the axial rotation exposing every part of the earth's surface to the same amount of light and darkness.

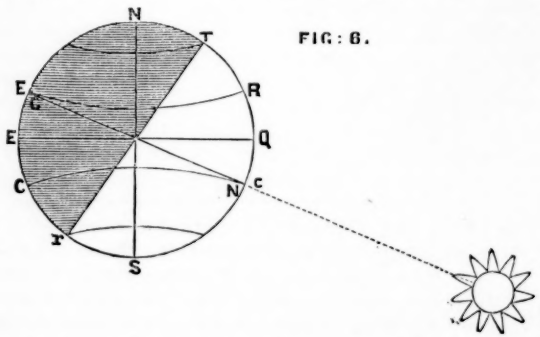


FIG: 6.

Fig. 6 shows the sun over the Tropic of Capricorn, as he is on the 21st of December, having the greatest south declination he attains, and explains the southern summer, and the short days and long nights of our winter. Here no portion of the surface included in the Antarctic circle can escape from the sun's light, and the phenomenon of the sun continually above the horizon will be witnessed by any person reaching a high southern latitude, as well as in the north, which has hitherto claimed our attention.

Let us sum up the teaching of these diagrams. To all places at the equator the days and nights are always of equal length. To all other places, except the poles, the days and nights are never equal, except at the equinoxes. To all parts of the world the days and nights are equal at the vernal and autumnal equinoxes, about the 21st of March and 23rd of September, when the sun enters the signs Aries and Libra, and has no declination.

To all places having the same latitude, the days and nights are always of equal length at the same particular time of year.

To all places north of the equator, the longest day and the shortest night are when the sun has his greatest north declination, and is on the Tropic of Cancer; and their shortest day and longest night when the sun has his greatest south declination, or is on the Tropic of Capricorn. In southern latitudes the reverse is the case.

To all places at the Arctic and Antarctic circles, when the sun has his greatest declination, he appears without setting for twenty-four hours, the length of their longest day, although the continuous daylight may last for weeks, as the sun sinks so little below the horizon that the twilight is sufficient for all purposes throughout the night. To all places within those circles the length of the longest days and nights increases the nearer the places are to the poles.

At the north pole, from the 20th of March to the 23rd of September, the sun is constantly above the horizon, and below it through the opposite interval. There is, therefore, during the whole year, but one day and one night, each of six months duration; but no one has yet reached the pole to experience this effect. In speaking of the long and dreary winter night, lasting for many months, which these illustrations show to be the lot of polar regions, we should not lose sight of the compensating influences. Thus, although the sun may be for months below the horizon, still he is rarely as much as 18 degs. lower than that circle, and therefore, owing to the existence of an atmosphere and its property of refraction, the amount of twilight is very considerable; and if we remember how strong this is during our summer, when for one month before and one after the longest day, we are said to have "no real night," the importance of this beneficial arrangement becomes manifest.* Again, the full moon is always opposite to the sun, and

* As far as 84½ degs. north latitude, the sun approaches within 18 degs. of the horizon at mid-winter, and therefore relieves the long night of three or four months, every twenty-four hours, with a short twilight. Even at the North Pole the sun is not more than 18 degs. below the horizon, till November 12th, and comes within that distance again on January 29th; the 78 days between being the only period of total night. From September 21st to November 12th, and from January 29th to March 21st, although the sun is absent, there is twilight.

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as the sun is below the horizon, the moon will be for a considerable period in each month, and that before and after the full, when her light is greatest, always shining, only sinking below the horizon when in the crescent form, and giving little light. Added to these constant phenomena are the brilliant displays of Aurora, common to such latitudes, and the beauty of the icy scenery, and we may yet understand that even in these regions there is an amount of physical and intellectual enjoyment to be derived from the bounty of the Creator, who has left no district without its charms.

Such are the astronomical causes of the Midnight Sun. They may be condensed into the statement, that within the polar circles the sun becomes circumpolar, for a period increasing with the latitude; and if we pay attention to the constellations, which are so situated with respect to ourselves as to be circumpolar, and also watch how very near the sun sets to the north point of the horizon, on its western side, at midsummer, and how, in a few hours, he rises again close to the north, on the eastern side, having, as it were, only just dipped out of sight—we shall readily undertand how a journey of a few hundred miles further north may bring us to a position, where, having reached the lowest part of his apparent daily path, he begins to ascend without ever having been lost to the gaze of the observer. The only difference between the sun and stars is, that they have always the same declination, and if circumpolar at a place at all, are always so; but the sun ranges from $23\frac{1}{2}$ degs. south, to $23\frac{1}{2}$ degs. north; and it is only when having north declination that he can be circumpolar to any part of the northern hemisphere, and *vice versa*.

Of the actual appearance of the Midnight Sun it is hardly necessary to speak here. All my readers have seen, or will see descriptions of the effect in the books of northern travel they may come across, and these accounts vary with the temperament of the traveller. Even fiction has borrowed the phenomenon for an incident. The charming Swedish novelist, Frederika Bremer, in her tale of *The Midnight Sun*, takes her characters on a pilgrimage to the mountain of Avisaxa, in Lapland, to behold the glorious sight, which is not, however, described in detail, the authoress being more occupied with the emotions of her ideal personages than with the aspect of Nature, although the beauty of the scene is there indicated by a few graphic touches. Our "Old Bushman," in his *Spring and Summer in Lapland*, after indulging in the poetical reflections called up by the glorious scene, says:—"In the north-east, where the fells were lower, the sun shone out of an unclouded sky, apparently about a foot from the horizon's edge—an angry, sullen, lurid globe of fire, without appearing to emit a single ray

of heat, for we could stare him in the face without winking. He appeared to me to go down about due north, and, without rising or sinking,* for nearly an hour, to travel eastwards, when he gradually rose and assumed his wonted splendour." We thus see that Longfellow is in error when he represents a person looking "southward" for the Midnight Sun, as both theory and observation show it is seen in the north.

The author continues, in language which is worth quoting :— "Never did I feel my own insignificance so much as when I descended the fell, and left this grand scene behind me. Place man in cities among his finest works of art, among his manufactories and machinery; bid him jostle his way through the human crowd among whom he lives, and his lip may curl with pride and self-satisfaction as he gazes triumphantly on some master-stroke of ingenuity, or chuckles at the success of some mighty speculation. It is then that he rises, as it were, in his own estimation, superior to his fellow man, and for the moment seems almost to forget that he is mortal. But place such an one in a scene like this at the hour of midnight, and let him see if his self-pride will not receive a check! He will now be able to compare the most stupendous works of his hands with the works of Nature, and then let him strike a balance. His choicest works of art can scarcely vie in beauty with the meanest wild flower he heedlessly crushes under foot, and as for his boasted superiority over his fellow man, why, in this rude spot the little untaught Laplander is worth a dozen of him."

Perhaps one of the most unlikely places to expect the Midnight Sun to make its appearance would seem to be the pages of Thomas Carlyle, but, strangely enough, in *Sartor Resartus* he conducts his clothes philosopher, Teufelsdrockh, to the solitude of the North Cape, on a June midnight, and writes (with which we must conclude) thus :—"Silence as of death—for midnight, even in the Arctic latitudes, has its character: nothing but the granite cliffs ruddy-tinged; the peaceful gurgle of that slow, heaving polar ocean, over which, in the utmost north, the great sun hangs low and lazy, as if he, too, were slumbering. Yet is his cloud couch wrought of crimson and cloth of gold; yet does his light stream over the mirror of waters like a tremulous fire pillar, skirting downwards to the abyss, and hide itself under my feet. In such moments, solitude

* This is probably due to the effect of refraction, which, as the sun approached the dense lower strata of the atmosphere near the horizon, would tend to raise his disc very considerably, and the lower part to a greater extent than the upper. For an explanation of refraction, and any other technical astronomical terms used in this paper, the reader may consult the article on Precession previously referred to.

also is invaluable; for who would speak, or be looked on, when behind him lies all Europe and Africa, fast asleep, except the watchmen; and before him, the silent immensity, and Palace of the Eternal, whereof our sun is but a porch lamp!"

MOSSES—GRIMMIA AND SCHISTIDIUM.

BY M. G. CAMPBELL.

WHILE the "Fair Maids of February,"* the "admired of all beholders," tremble on our hedge-banks, and hang their modest heads, as if anxious to shun the gaze they cannot but attract, the elegant *Grimmia orbicularis*, or *round-fruited Grimmia*, still more worthy of regard, may be found, albeit all unnoted, spreading its dense tufts upon calcareous rocks, sometimes mixed with its cousin of more common occurrence, *Grimmia pulvinata*, or the *grey-cushioned Grimmia;* and sometimes in compact family groups, braving alone the storms of its weather-beaten home.

The genus named in honour of Grimm, a German botanist, consists of perennial mosses, allied at once to *Schistidium* and to *Racomitrium*. They grow upon rocks and walls, sometimes in compact tufts, sometimes loosely, and irregularly cæspitose, with capsules which vary much both in form and position, being in some species immersed and shortly pedicellate, in others, excerted, erect, cernuous, or pendulous, on a straight or on a curved pedicel, solitary, and with a mitriform calyptra reaching below the lid; sometimes five lobed at the base; sometimes dimidiate, or cloven on one side. The inflorescence is monoicous or dioicous; at first both flowers are terminal, but at length, by growth of the stem, the gemmiform barren flower becomes lateral.

The leaves are semi-amplexical and imbricated at the base, while they spread in the upper parts, and generally terminate in a longer or shorter semi-transparent white hair-point, usually denticulate; the upper leaves largest and tufted at the summit of the stem. The peristome consists of sixteen rather large lanceolate teeth, convex externally, and trabeculated; bitrifid, spreading, or sub-erect when dry; either purplish, pale red, or yellowish brown, and slightly hygroscopic. The columella instead of being deciduous and falling off with the lid, as it does in *Schistidium*, shrinks up into, and remains in, the ripe capsule, a circumstance which forms the chief difference between *Grimmia* and *Schistidium;* the latter might therefore be classed as a sub-genus of Grimmia, with a

* The Snowdrop—*Galanthus nivalis.*

columella adhering to the lid, and all its capsules sub-sessile and immersed.

Grimmia orbicularis, of which we give a magnified illustration, with stem leaves very highly magnified, grows on calcareous rocks, with densely tufted stems, and crowded oblong - lanceolate leaves, having long diaphanous points, and small dot-like cellules, in straight longitudinal lines. These cellules are, however, enlarged towards the basal margins, and as they descend the stem the leaves are less crowded, diminish in size, become destitute of the bristle, and are even somewhat obtuse pointed.

Grimmia orbicularis.

The capsule is roundish, on a pale yellow curved fruit-stalk; the capsule itself as it ripens passes from pale yellow to bright red, is smooth and glassy while recent, but obscurely striated or ribbed when dry; the walls of a rather thin or semi-opaque texture, with a narrow annulus and a very short mammillate, but never rostellate lid. The teeth of the peristome rather short and broad, trifid, sometimes quadrifid at the apex, semi-opaque, of a pale red, rather distantly marked externally with transverse bars, and much perforated or crib-rose towards the base; they are erect or converging when dry. The calyptra is dimidiate and soon falls away.

Though *Grimmia orbicularis* ripens its fruit at an earlier period, it sometimes, as we have before said, grows intermixed in the same tuft with a more common species, *Grimmia pulvinata,* or the *grey-cushioned Grimmia,* which is commonly found on walls and roofs, as well as upon rocks; it, too, grows in densely tufted round patches, with branching stems, from half an inch to an inch in height, and with leaves very much resembling those of the preceding species, being elliptic-lanceolate, suddenly attenuated and piliferous, terminating in long white hair-points, but the leaf is broader than in *orbicularis;* carinate, with a somewhat stronger nerve, which vanishes below the hair-points, and though both are hoary from their white terminal points, the foliage of *pulvinata* is of a more yellowish green; that of *orbicularis* has a bluer hue, and more dingy appearance.

But however the naked eye may be deceived, placed under the microscope the fruit at once reveals the species. The capsule of *G. pulvinata* is less round, and instead of the bright red, has a dull reddish-brown colour, with rather thick and opaque walls, eight ribbed when dry, a lid conical below, but with a straight beak about half as long as the capsule. The calyptra not dimidiate, or splitting one side, but about five-lobed at the base, and the annulus broader and compound, but quickly unrolled after the fall of the lid. The teeth of the peristome are lanceolate, deep purplish red, more or less spreading when dry, and, as in *orbicularis*, often cloven at the apex, which circumstance at one time occasioned its being confounded with the *Dicranums*.

The fruit of *G. pulvinata* is drooping, forming as it were the tasselled point of a little hook reversed, which the seta greatly resembles; or perhaps it were better to liken it to the curve at the upper end of a shepherd's crook; and it is usually concealed by the leaves when growing; it ripens in March and April.

A variety of this moss, termed *obtusa*, has been found on St. Vincent rocks, near Bristol, and on Conway Castle rock, having shorter stems, a shorter capsule on a shorter pedicel, teeth of the peristome shorter, and a sharp conical lid, obtuse, or mammillated.

Grimmia spiralis, or the *spiral-leaved Grimmia*, has also lanceolate leaves, tapering into long diaphanous hair-points, but it cannot be confounded with either of those mentioned from its slender, almost filiform stem, and its leaves being spirally imbricated or contorted round the stem when in a dry state.

It grows on dry exposed Alpine rocks; has been found on the east side of Slemish mountain, county Antrim, Ireland; on Ben Lawers, and other mountains in Breadalbane; on the Grampian mountains, and on Snowdon. Upon its native rocks it forms large dense tufts, which, however, readily fall asunder when torn from them; of somewhat fragile texture, it reaches from half an inch to one inch and a half in height, the stem more or less branched, and not unfrequently proliferous, with lateral flagelliform shoots. The upper leaves and the perichetium alone terminate in hair points; those of the stem are slightly spreading, incurved above the middle, and are somewhat recurved in the margin; the perichætial leaves longer, broader, and concave.

The capsule is small, of a pale, reddish brown, ovate or obovate in form, and having eight furrows in the dry state; less marked, almost inconspicuous when growing. The lid is short, apiculate, scarcely rostellate; the annulus compound, and

dehiscing in fragments; the teeth of the peristome rather long, of a purplish red, bifid and recurved when dry; the calyptra conico-mitriform and five-lobed at the base. The moss is, however, much oftener found without than with the fruit.

Grimmia torta, or the *twisted-leaved Grimmia*, seems like an exaggeration of *G. spiralis*, which it greatly resembles in its mode of growth; but it is a more robust species, its incoherent tufts, of a rich olive brown, rising to the height of from one to two inches. The leaves are more contorted when dry, and when they have diaphanous hair-points—a circumstance of only rare occurrence—those points, instead of being long, are very short; the leaves are also acutely carinate, and channelled along the nerve, so as to be almost conduplicate. No fruit has as yet been met with, nor any flowers observed, though the plant itself is plentiful on rocks in England, Scotland, Ireland, and Wales; but among the leaves near the top of the stem, and sometimes adhering to the back of a leaf, are frequently found jointed thread-like filaments, whose precise office is not yet fully ascertained.

Grimmia trichophylla, or the *Hair-pointed Grimmia*, was discovered by Dr. Greville on stone walls near Edinburgh. It has since been found not unfrequent in similar situations throughout Britain; and Dr. Taylor met with it in Ireland; but it does not commonly occur in fruit. It grows in soft, lax, yellowish green patches, with stems of from a quarter of an inch to an inch long, rooting only at the base, and with leaves spreading from an erect base, flexuose, and incurved towards the apex, slightly crisped when dry, and with the margin nearly plane above, but recurved below. The fruit-stalk is yellowish, longer than the perichætial leaves, but curved, as in *G. pulvinata*, while growing; when dry, flexuose and nearly erect. The beautiful little capsule is elliptical or ovate-oblong in form, its walls rather thin, furrowed or angular when dry, and of a pale brown; the lid has a rather long, straight beak. The annulus is large and dehiscent, the calyptra conico-mitriform and lobed at the base, while the teeth of the peristome are densely barred, sometimes entire, sometimes bifid. The laxity of its tufts, and the gradually tapering leaves, sufficiently distinguish it from *G. pulvinata*, even when not in fruit, the leaves of the latter being suddenly and abruptly contracted into hair-points. The inflorescence, too, is dioicous, while in *pulvinata* it is monoicous.

Another Grimmia with curved seta, growing on subalpine rocks in Scotland, Wales, and Cornwall, but of less frequent occurrence, is *Grimmia Shultzii, Shultz's Grimmia*. It is a more robust species than the last, has more crowded leaves,

which are subsecund and spreading, with recurved margins, and which gradually taper into long, rough, diaphanous, glossy hair-points, which spread outward when in a dry state. The capsule, too, is thicker and shorter, and attached to a shorter fruit-stalk; but the red teeth of the peristome are longer, more tapering, and more deeply cloven—indeed, so very long and slender are they, that the upper portion not unfrequently breaks off, and remains attached to the fallen lid; the annulus is broader, and whereas the inflorescence of *G. trichophylla* is dioicous, that of *G. Shultzii* is monoicous, the barren gemmiform flower being always found in the vicinity of the perichætium. It fruits in April and May.

Growing on shady or moist alpine rocks in Scotland, Wales, and Ireland, in large green or brownish patches, we have *Grimmia patens*, or the *tall alpine Grimmia*, its stem reaching from two to four inches long, or even more, branched and fastigiate, nude of leaves in the lower part, and decumbent at the base; the leaves are muticous, *i.e.*, destitute of the slender point; they are of firm texture, erect and rigid when dry, rather glossy, the margin recurved below, and carinate, with a stout nerve dorsally two-winged, by which curious peculiarity the species, even in a barren state, may be easily recognized. The perichætial leaves are shorter than the rest, wider below, and somewhat sheathing. The capsule is of a pale brown, smooth at first, but distinctly furrowed when dry, and attached to a rather short, pale, curved fruit-stalk, the annulus large and distinct, teeth of the peristome long and bifid, or bi-trifid at the apex, confluent at the base; lid with rather a long beak, sometimes straight, sometimes oblique, and the calyptra usually five-lobed at the base. Its season of fruiting, like that of *G. Schultzii*, is April and May; but, from the growth of innovations in the stem leaving the fruit in a lateral position, it often escapes observation.

Grimmia Donniana, or *Donn's Grimmia*, grows in small, round, hoary tufts, with branched stems that seldom exceed a quarter of an inch in length. The leaves are narrowly lanceolate, and tapering into roughish diaphanous hair-points scarcely half the length of the entire leaf, which is erecto-patent when growing, erect and slightly flexuose when dry, carinate, of a dark green, with a slightly-thickened border, the very obvious nerve prominent at the back, and continued to the hair-point. The perichætial leaves are longer than the others; the capsule quite erect, oval oblong, of a pale yellowish brown, with thinnish walls, and sub-excerted: in one variety immersed. The lid is short, conical, seldom more than one-third the length of the capsule, more or less obtuse, sometimes slightly apiculate, entire, and without any marginal groove for the annulus, which is persistent. The teeth of the peristome are rather broad,

densely barred, sometimes perforated, but rarely bifid. It is found on rocks and walls in mountainous districts, is abundant near Llyn Ogwen, Carnarvonshire, and elsewhere about Snowdon, and was discovered near Forfar by Mr. George Donn, after whom it is named. It fruits in March, April, and October.

Grimmia ovata, the *oval-fruited Grimmia,* is a larger species, having stems half an inch long or more; more or less compactly tufted, branched and fastigiate, with leaves of firmer texture, more opaque, more erect when dry, and more crowded than in the last species; the margin in the lower part recurved, which it is not in *Donniana,* the nerve broader, but less defined, and less prominent at the back, and the perichætial leaves more erect and sheathing. The capsule is of firmer texture, erect, oval, of a darker hue, being reddish brown, and excerted on a longer pedicel; the annulus is large and dehiscent, and lodged in a groove on the margin of the lid, which is longer and rostellate. It too is found on alpine rocks, particularly on the Breadalbane and Clova mountains. On Snowdon it is rare. Fruiting season, October and March.

Another very distinct species, with dark green foliage, and densely tufted stems of little more than half an inch long, was discovered on trap rocks in King's Park, Edinburgh, by Mr. R. Brown, and to which the name of *Grimmia leucophœa,* or *hoary Grimmia,* has been assigned. While growing, the leaves are widely spreading; but when dry they are closely imbricated, concave, ovate, or elliptical, with plane margins, the upper ones suddenly tapering into very long hair-points, the lower ones muticous. The capsule is elliptical or oblong, of a reddish brown, erect and excerted, perfectly smooth when dry, and with thick walls, the lid variable in length, conico-rostellate, sometimes conical and mammillate, not quite half as long as the capsule, and wearing a calyptra five lobed at the base, and covering one-third of the capsule. The teeth of the peristome are densely barred, the bars externally prominent; they are also deeply bi-trifid and perforated, and are spreading when dry.

G. leucophœa fruits in April. It has been found in various localities—on the coast of Fife; at Fairhead, on basalt; Abbey Craig, near Stirling; and at Salcombe, in Devonshire.

Grimmia unicolor, or the *dingy Grimmia,* grows also on alpine rocks, in broad, incoherent lurid patches, with stems from one to two inches long, more or less branched, the branches flexuose, brittle, and fastigiate, leafless below, but often having slender ramuli, with small ovate imbricated leaves, like those of *G. spiralis,* but more crowded. The leaves of this

species are obtuse pointed, and destitute of the bristle, with a margin so inflexed that the upper part of the leaf might be called semi-cylindrical, and having a broad nerve which reaches to the apex, and so predominating as scarcely to be distinguished from the laminar substance of the leaf. The capsule is ovate, smooth, yellowish-brown, erect, or slightly oblique, and having a lid with a straight or inclined beak half as long as the capsule, annulus large and dehiscent, calyptra dimidiate and rather oblique.

Grimmia atrata, or the *black-tufted Grimmia*, somewhat resembles the last, growing to about the same height, but in more compact tufts, with blackish glossy leaves, rather less rigid than in *unicolor*, less obtuse, with a thinner nerve, though more distinctly defined, and carinate, which the leaves of *unicolor* are not. The fruit-stalk is rather thicker and longer, the capsule longer, and becoming blackish when old; the lid has a shorter beak, and the calyptra is fugacious. The inflorescence in both is dioicous, but *Grimmia atrata* is the more rarely met with. Snowdon and the rocks above Glen Callater have been given as its habitats. It fruits in spring and autumn.

The three other British species of Grimmia have been arranged under the head of *Schistidium*. They differ from those already described in very little more than having immersed and almost sessile capsules, whose columella adheres to, and falls away with their lid.

The term Schistidium is derived from *σχίζω, I split*, or *shiver to pieces*, in allusion to the lacinated base of the calyptra, which is also so small as scarcely to cover the lid.

Schistidium confertum, or the *close-tufted Grimmia*, is densely cæspitose, with ovate lanceolate acuminate leaves, of an intense green colour above, blackish below, the upper ones only shortly hair-pointed, erect and lurid when dry, deeply and acutely channelled above, and with a strong nerve dilated at the back; the capsule oval or roundish, with a shortly rostellate lid, no annulus, and teeth much perforated. It is found on trap or sandstone rocks, and fruits in February and March.

Schistidium apocarpum, or the *sessile Grimmia*, has considerable resemblance to *S. confertum;* the capsule is, however, larger, of darker hue and thicker texture, that of *confertum* being almost pellucid. *S. apocarpum*, too, is taller, more loosely cæspitose; in the larger varieties dichotomously branched, and often procumbent; and the firm, opaque, shortened capsule has a wide mouth in the dry state: the teeth of the peristome are rather long, and of a dark red, those of *confertum* of a pale red or orange colour. The lid is convex, with a short inclined beak, and the calyptra

torn into about five lobes at the base. There are several varieties of this moss with slight but persistent differences. It is found on rocks and walls, sometimes on trees, and fruits in February and November.

The dense dull green or brownish tufts of *Schistidium maritimum*, or the *Sea-side Grimmia*, scarcely average an inch in height, but have longer, narrower, and more rigid leaves, of a glossy and almost horny consistence, and incurved when dry, especially the perichætial leaves, which, though not hair-pointed, have a strong excurrent nerve, of a reddish brown colour. The capsule is soft, of a pale bright hue, obovate-truncate in form, without an annulus, but with large teeth much perforated, and a rostellate lid. It fruits in November and December, and its rigid, strongly-nerved leaves sufficiently distinguish it from the preceding. It is found on rocks near the sea, but, it is said, "seldom, if ever, on such as are calcareous."

Thus we have described the whole family, as at present known and arranged, genus and sub-genus, fifteen in number, and we can promise, from experience, that whoever will take the trouble microscopically to examine their peculiarities, and verify our assertions, will open to themselves a source of intense and abiding interest.

GUNS AND PROJECTILES.

It is probable that through the artillery experiments carried on by the Government, and through the experience afforded by the siege operations of the American war, the attention of the public will once more be strongly drawn to the question of arms and projectiles, and it may therefore be interesting to many readers if we lay before them a few of the chief facts and arguments pertaining to the question, and divested of those technicalities which so often deter students from attempting to understand mechanical problems.

A little investigation will show that fire-arms furnish a variety of conditions under which the laws and effects of motion may be conveniently exhibited, and it is certain that no important improvement can take place in the military and naval apparatus for attack and defence, without great benefit being indirectly conferred upon the arts of peace. We shall not attempt to trace the history of projectiles, but it may be as well at the outset to correct a popular mistake, that the rude fire-arms of our ancestors replaced the bow and arrow simply by reason of their superiority in destructive power. This was

certainly not the case, for while a trained archer was nearly certain to hit a man at 150 or 200 yards, and good shots could accomplish the same feat at double those distances, our soldiers when armed with the old Brown Bess were equally sure of missing any object that a street urchin could not easily hit with a stone. The bow and arrow must, however, have been a most inconvenient arm in actual war. Unless well made and taken care of, the arrows could not be depended upon. The bow was easily damaged and its string much affected by the weather. Moreover, the arrows were a bulky form of ammunition. Sixty cloth-yard shafts would make an awkward load, while the same number of the old fashioned cartridges could be easily carried in a small pouch, and were much more easily kept in good condition. The introduction of the bayonet also gave the musket a great advantage over the bow, for while the latter was worse than useless, except for the discharge of its projectiles, the former, when not wanted as a fire-arm, became a formidable pike.

As a weapon to hit anything with, except by accident, the old musket was one of the worst ever contrived, and the old rifle by which some of its errors were corrected, was not much better beyond a couple of hundred yards. Lest this should seem an exaggeration we will recite a few of the often quoted facts which Sir J. Emerson Tennent brings once more before the public in his interesting popular work entitled the *Story of the Guns*.* He reminds us that during the Caffre war, 81,011 cartridges were fired in one engagement in order to make five-and-twenty of the enemy fall; while, during one of the great battles of the French war, a volley fired at thirty paces only brought down three men out of a squadron of cavalry charging a square. Trials made in 1838 showed that a target three feet wide, and nearly twelve feet high, was missed by one quarter of the balls at 150 yards, and at 250 yards not a single ball out of ten hit it when its width was increased to six feet.

The conditions necessary for missing the object shot at, were thus admirably fulfilled, and we may learn something by ascertaining what they were. In the first place the projectile was a round ball, fitting the barrel loosely and jammed in with a paper cartridge. After the explosion of the powder it would bump up and down, or from right to left in the barrel, and rotate besides. When it left the muzzle no one could guess whether the deviation from the true course would take it too high or too low, too much on one side or too much on the other. In addition to this unknown and unknowable amount

* *The Story of the Guns*, by Sir J. Emerson Tennent, K.C.S., LL.D., F.R.S., etc. *Longmans.*

of initial error, it would suffer further equally unknown and unknowable deflections as it went along. Its centre of gravity might not have been co-incident with the centre of its sphere; and if it were so when it entered the barrel, the shape was sure to suffer from the explosion, so as to throw it out. There were also more refined reasons why a round ball could not be depended upon to move in one plane during any considerable flight.

In the early rifles the ball was driven into the barrel so as to fit tight, and one source of error was thus removed. Moreover, it was found that the grooving of the rifles could be made to spin the ball about an axis parallel to the sides of the barrel and coinciding with the plane of its intended flight. Under these circumstances, and by avoiding crushing the ball out of shape in the process of loading, very fair shooting could be accomplished at from fifty to a hundred yards, and moderately bad shooting at twice that distance. During the continental war it was a great achievement if anybody was made unsafe by rifles at four hundred yards, and the artillery was proportionably ineffective as a destructive weapon.

Among the earliest people to introduce greater precision into their arms were the Americans and the Swiss, both of whom adopted principles pointed out by Robins, the mathematician, and even by Newton. Without giving them exclusive credit, they practically demonstrated that projectiles must not be round, if the best effect was to be obtained. A round ball is easily started with a high velocity, but the surface of resistance it opposes to the air is so great in proportion to its moving power* that it soon takes to a slow trot, and then comes to rest. If three or four balls be placed one behind the other, it will be seen that so long as they touched each other, and moved straight forward, the front one would clear the way, and the others would pass with comparatively little opposition. This is, in popular language, the philosophy of elongated projectiles; but to enable them to act well they must always move in one plane. As long as they go face foremost, they have, as compared with a round ball, the advantage (supposing the velocity to be the same) of the additional momentum due to their greater weight, while their area of resistance is not proportionably increased.

The mechanical problem which the improvers of the rifle had to solve, was to obtain the best form of elongated projectile, and prevent its turning over or going side foremost in its flight. It was soon found that a long conical projectile could be made to move with its smallest and lightest end foremost for many

* The momentum of a projectile is equal to its weight multiplied by its velocity.

hundreds of yards, provided it was made to revolve with sufficient velocity about its long axis all the time. So successful were the Swiss in applying these principles, that, as Mr. Wilkinson showed in an able pamphlet published in 1822, they could put twenty bullets in succession into a target ten inches square, and 200 yards off, and at 800 paces they put forty bullets into a target fifty-five inches square. At 1000 paces, on a calm day, 100 bullets in succession struck a target eight feet six inches square.*

Our Government, from its unfortunate antagonism to science, was, of course, one of the latest in the field, and then, after an expensive blunder with the so-called "Minie pattern," it adopted the Enfield, an immense advance on the former rifle, but constructed in defiance of the principles thoroughly established by scientific experimenters. The faults of the Enfield rifle were, and are, its feeble power of spinning a long projectile, and the consequent necessity for using one of a clumsy shape that moves like a cart-horse, and in a course needlessly elevated above the ground.

Mr. Whitworth—that great master of accuracy in things mechanical—soon after turning his attention to the subject, produced the most perfect rifle yet seen. As might have been expected from his extraordinary talent in devising the best mode of ensuring a close approximation to mathematical truth in workmanship, he is able to produce uniformity of excellence to a wonderful extent. As stated in Sir Emerson Tennent's work, the principle of Mr. Whitworth's success "was found to consist in an improved system of rifling, a turn in the spiral four times greater than the Enfield rifle; a bore, in diameter, one-fifth less; an elongated projectile of a mechanical fit; and last, but not least, a more refined process of manufacture." In the Enfield rifle "the spiral course to be traversed by the bullet makes one turn round the interior of the barrel in advancing six and a half feet; but this moderate degree admits only of the use of short projectiles, as long ones turn over on issuing from the muzzle, and short ones become unsteady at great ranges. Mr. Whitworth adopted with his reduced bore one turn in twenty inches, which he found ample for securing a comparatively steady flight over a range of 2000 yards."

Mr. Whitworth's rifling is commonly described as hexagonal; but, as Sir Emerson Tennent says, this is scarcely correct. "He converts the entire inner surface of the barrel into something approaching a hexagon, leaving in the middle of each division of the plane surface a small curved portion coincident

* Many writers confound the Swiss *military* rifle with that employed in village target shooting, which is not constructed for long range.

with the original circular bore of the gun, and rounding the angles to contribute to the strength of the barrel." His projectile is made to correspond by its polygonal and sloping surfaces with the rifling of the barrel.

Having been more attentive to scientific considerations than the contrivers of the "Enfield," Mr. Whitworth naturally obtained far greater success, and we cannot describe this better than in the words of Sir Emerson Tennent, who observes:

"The Whitworth rifle was first formally tried in competition with the best Enfield musket at Hythe, in April, 1857. . . . . The success was surprising; in range and precision it exceeded the Government musket three to one. Up to that time the best figure of merit obtained by any rifle at home or abroad was 27: that is to say, the best shooting had given an average of shots within a circle of 27 inches mean radius at 500 yards distance; but the Whitworth lodged an average of shots within a mean radius of four and a half inches from the same distance; thus obtaining a figure of merit of $4\frac{1}{2}$. At 800 yards its superiority was 1 to 4, a proportion which it maintained at 1000 yards and upwards. At 1400 yards the Enfield shot so wildly that the record ceased to be kept; and at 1800 yards the trial ceased altogether, whilst the Whitworth continued to exhibit its accuracy as before."

It would not be just to the memory of the late General Jacob to omit the fact that, by employing a well-shaped projectile and a high twist in his rifle, he had achieved a success almost as remarkable as that of Mr. Whitworth. In 1855 he recommended a rifle with a twenty-four gauge bore, having four grooves, and carrying a projectile of a curved conical form, resting on a short cylindrical base, and he states that with it "a tolerably good shot can certainly strike an object the size of a man once out of three times at 1000 yards distance, and the full effective range is near 2000 yards—the ball at that range flying with deadly velocity."*

An important question connected with a high twist of the rifled barrel is, what influence is exerted on the force of the projectile and its range by the rapid rotation which it induces? If it lessened the rapidity of its flight, so as to diminish its destructive powers, it would be open to grave objections. It is necessary in replying to this inquiry to pay attention to the circumstances under which the rapid rotation is produced. If the friction of the projectile against the sides of the barrel is greatly augmented, a considerable loss of force and range must be the result; but by adopting different systems of rifling and different projectiles, it is easy to communicate a similar amount of spin or rotation with widely different proportions of

* *Rifle Practice*, by Major John Jacob, C.B. *Smith, Elder, & Co.*

loss from this source. The practical question therefore is, how to communicate a high velocity of rotation with the smallest amount of friction, and up to the present time this problem has been most successfully solved by Mr. Whitworth. In an experimental barrel, twenty inches long, Mr. Whitworth made twenty turns, so that when the projectile was fired from it, the rotation velocity was much greater than the velocity of the forward movement, and yet it penetrated seven inches of elm. In a paper quoted by Sir Emerson Tennent, Mr. Whitworth says, that "in some projectiles I employ, the rotations are 60,000 a minute. In the rotation of machinery 8000 revolutions a minute is extremely high, and considering the *vis viva* imparted to a projectile as represented by a velocity of rotation of 60,000 revolutions, and the velocity of progress 60,000 feet per minute, the mind will be prepared to understand how the resistance of thick armour plates of iron is overcome, when such enormous velocities are brought to a sudden standstill." The smallest amount of friction will take place between smooth, nicely adapted, perfectly clean and well lubricated surfaces, fitting tight enough to prevent the escape of the gasses that impel the projectile, but not jammed against each other with needless force. The inside of a good rifle should therefore have a shape that is easily kept clean, and in this respect Mr. Whitworth's modified hexagon, and Mr. Lancaster's oval, possess an advantage over all intricate groovings.

A cannon is merely an enlarged shoulder gun, to be fired from a mechanical stand, instead of from the human body, It however presents peculiar difficulties in its requirements. In the first place, its size is an obstacle to perfect workmanship. It is comparatively easy to forge a rifle barrel weighing from five to eight pounds, without any flaws or defects; but the same process cannot be repeated with the same certainty with a barrel weighing several hundred-weights, or tons. The cast iron ordnance was an attempt to make quantity of material a substitute for quality, which had to be abandoned when greater perfection of performance was required. Then homogeneous iron carefully forged, together with various modes of strengthening the barrel by additional layers of metal, either welded on, or simply forced on in close contact, had to be resorted to. An interesting work might be written on this part of the question, and on the various modes that have been adopted with greater or less success; but we must not pursue the subject now, or we should be led too far away from other considerations. Let us pass to a second peculiarity in cannons as compared with muskets—the necessity for firing hard iron projectiles, instead of soft lead, that readily accommodates itself to rifle grooves. If a cylinder of lead or any other soft metal is

dropped into a barrel which it loosely fits, the moment the powder is ignited it "hammers up." That is to say, its nether extremity receives such a rapid thump that the mass has no time to evade its force by getting out of the way, and consequently the projectile is instantly made thicker and shorter. An iron cylinder would, with an ordinary charge of powder, be so slightly acted upon in this manner, that it would not be driven into the grooves, and if it were so driven, the friction would be tremendous in the subsequent attempt to force it through the barrel. Mr. Lancaster proposed elliptical iron shot, and barrels of an elliptical form, with the major axis twisting in a spiral as it descended. This plan achieved considerable success with rifles and leaden projectiles; but failed when applied to cannon. General Jacob proposed four-grooved cannon, and four projections or wings from the balls. Sir William Armstrong, with great skill, constructed cannon to fire compound projectiles—iron for strength and penetration, and lead to take the rifling, as in small arms.

It is impossible to look at an Armstrong gun without great admiration for the beauty of its manufacture; and its performance is astounding for accuracy if compared with most other patterns. Independent, however, of the defects of its method of breech-loading, it seemed marked out from the beginning as a provisional weapon only. Projectiles composed of two metals could only be regarded as substitutes for the best mode of making and discharging projectiles made entirely of iron or steel. The grooving of the Armstrong gun, although very beautiful, was a recurrence to a plan not found to be the best in small arms. A multiplicity of small sharp grooves with a moderate twist marked the weapon as likely to lose much power by needless friction, and not to be able to attain a maximum of velocity or range. So successful has Mr. Whitworth been in this matter that, as Sir Emerson Tennent states, "The average initial velocity of a sixty-eight pound spherical shot thrown from a smooth bore, with a charge of one quarter its weight of powder, is 1600 feet in a second, and this it very speedily loses. On the other hand, with a shot of the same spherical form, but rifled to fit the gun, Mr. Whitworth's obtains an initial velocity of 2200 feet in a second." This increase of velocity is obtained by the accurate fit of the projectile, and consequent prevention of the escape and waste of the gases into which gunpowder is resolved. In the Armstrong pattern the gain would be less, because the friction is so much more. Sir William estimates the force required to squeeze his twelve-pound shot into the grooves of his cannon at *several tons*, "whereas in the Whitworth gun, the shot being already rifled and fitted to the bore, it may be started and drawn through the barrel with a silken thread."

XUM

The advantage of great velocity and capacity for extreme range, is not confined to distant shots, as it is a most important element in facility of hitting any object whose distance is not exactly known. Suppose it possible for a projectile to move in a *straight line* from the muzzle of the gun to the object shot at, no change of elevation would then be required for different distances. Now the nearer you can approximate the path, or trajectory, of a projectile to a straight line, the less it matters whether you guess the distance a little more or less. If the projectile goes high up in the air above the object, and then rapidly tumbles down to it in a descending curve, accurate shooting may be managed at targets whose exact distance is known; but an error of a few yards in guessing the distance and arranging the elevation would cause an object that was not very tall to be entirely missed. Again, in firing at an advancing body of men, the ball that goes up in the skies and then plumps down, is very unlikely to hit more than one if the best aim be taken, while the comparatively straight-going ball may knock down a dozen, one behind the other.

We must now consider another point—the power of projectiles to penetrate iron plates or other shock-resisting medium. This needs, first, great velocity; secondly, sufficient weight and strength in the projectile; thirdly, such a shape as will enable the projectile to break through the resistance, and not be broken itself. Pointed shots fail against great resistance, because, at the moment of striking, their pointed ends, being unsupported, give way. Flat-headed cylinders appear to answer best, and, if proceeding quick enough, easily punch their way through targets like the sides of our "Warriors," which were supposed, until tried, capable of resisting any force. An interesting epitome of various experiments with the Whitworth and Armstrong guns is given by Sir Emerson Tennent, but we shall not dwell upon these incidents: first, because they are pretty well known; and secondly, because further experiments may throw them into the shade.

We will, however, recall two experiments, in one of which a solid hexagon shot weighing 129 pounds was fired from a Whitworth gun at 600 yards. It struck the target within an inch of a white spot at which it was aimed, and pierced $4\frac{1}{2}$ inches of iron, and shattered, though it did not pass through, 18 inches of teak lined with iron $\frac{2}{3}$ths of an inch thick, and supported by upright angle irons, that arrested its course. Mr. Whitworth afterwards fired a shell through the same target. When the projectile struck the target a bright sheet of flame was occasioned by the sudden arrest of such an amount of motion.

When rifle ordnance was first seriously discussed, it was

predicted that they would not do for shells; but Sir William Armstrong proved that, on the contrary, they would fire a more destructive kind than had been previously employed, while Mr. Whitworth demonstrated that if made of the right pattern, they could be easily driven through any of the iron ships in the navies of England or France.

When projectiles are fired from guns, their velocity diminishes as they proceed, and no attempt has as yet been successful to give the requisite accuracy to rockets, which supply their own motive power as they go along. Sir William Congreve did much, and Mr. Hall improved upon his plans; but no rocket has yet approximated to the accuracy of a shot receiving its impulsion from a charge of powder in a gun. An ordinary projectile suffers no change in the position of its centre of gravity during its course; but a rocket carries a composition that goes on burning, and thus it may be said to be continually discharging ballast, and shifting its weight. Whether this will ever be compensated, and whether it will also be found possible to regulate the direction and force of the gases discharged from its tail, we do not venture to say; but if some future Whitworth could perfectionate a rocket fired from a rifled gun, it would probably penetrate anything that could be made to float.

The size of ordnance is almost as important as their construction, and perhaps a rule might be laid down to use the biggest that all the circumstances conveniently permitted. There are cases in which small guns fired often, would be more advantageous than big ones fired at greater intervals; and it is certain that monsters could not be fired as often and as quickly as those of moderate size. In other cases, as in attacking ships or forts, size must be an important element of success—a single shell of great bulk being able to destroy any vessel it could penetrate, or blow up an immense quantity of earth or stone work. Should our engineers succeed in constructing really serviceable guns, capable of throwing 1000-pound shot or shell, ships might become simply floating stocks for one or more of such barrels, and in any case it may be doubted whether leviathan vessels that offer so much to shoot at, and are so difficult to manage, will maintain their ground.

We shall, in conclusion, say a few words on explosive substances, and their action. In dealing with a projectile you wish to communicate to it, *as a whole*, as much motion as you can. When your powder is exploded, a solid is suddenly converted into gases, which, in a highly heated state, are supposed to occupy more than 2000 times the original bulk. The velocity of the transition from the solid to the gaseous state is also enormous, though far less than in certain other compositions of

an analogous nature. Now it is possible to strike the base of the projectile and the sides of the gun with such force and velocity as to break up their cohesion; but this is destroying the carriage and the passenger instead of conveying him quickly to his legitimate destination. When we sit in a railway train and the engine starts, we feel a jerk as the coupling chains are extended, and the vehicles are pulled. If this jerk were greater than the chains would bear, they would be broken, and perhaps the carriage also, but we should scarcely move. If the engine, as it sometimes is the case, were placed behind, and it shoved the carriages too rapidly, they would be smashed without receiving much forward motion. This will explain why, with gunpowder, or its substitutes, too great a velocity of action will not answer. The chemical composition, the size of the grains, the mode of ignition, all influence the rate at which solid gunpowder is changed into heated gas. When it is intended to burn a given quantity of powder in order to communicate velocity to a projectile of particular weight, the preceding circumstances have to be considered, and also the best mode of packing the powder, whether it shall occupy a broader or a shorter column. The length of the barrel must also be proportioned to the quantity of powder and the rate at which it burns.

Hitherto, gunpowder has not been surpassed for practical utility in fire-arms, but recent Austrian experiments again revive the claims of gun-cotton, and perhaps other compounds, as yet unknown, may prove more convenient than either. Looking at this, and to other probabilities, we must not expect that we are to solve for ever the problem of the best gun and the best projectile. All that we can reasonably desire is, that, whether the skill of our nation is permitted to develope itself in peace, or unfortunately compelled to exercise itself in war, we may be amongst the foremost in science, and amongst the most ready to welcome useful novelties and cast old prejudies and ignorances aside.

AEROLITES WITH LOW VELOCITIES.

THE following is a translation of the principal passages of a letter by M. L. Sœmann, in *Comptes Rendus*, 4th January, 1864 :—

"I have the honour to present to the Academy the largest fragment that was picked up of two aerolites which fell on the 7th December last at Tourinnes-la-Grosse, nine leagues south of Louvain in Belgium. The desire to obtain good specimens for the scientific collections of Paris, caused me to visit the spot immediately after the event. The periodical *Les Mondes* published in its number for the 20th December, statements collected from ocular witnesses of the fall, and which differ little from similar relations. The largest stone was seen to shatter itself on the pavement of the village. Fragments were collected and carried off by different persons, but the greater part was reduced to dust and lost. The second stone was found two days afterwards in a fir-wood about two kilomètres from the village. It is from this aerolite I obtained the two large pieces which I place before the Academy ; the remainder, which was twice as big, seems to have been destroyed by persons who wished to see its inside. Both stones are exactly alike, except that some spots of rust soil the fragments of the first, which were exposed to the dampness of the earth before they were picked up. The clean stone is whitish-grey, of a fine close texture. Its density is 3·52, and disseminated through it are very small metallic grains, some of a fine silver-white, attracted by the magnet, and others, more numerous, of a bronze colour, not magnetic, but soluble in hydrochloric acid, with disengagement of sulphuretted hydrogen—characters indicating metallic iron and sulphuret of iron. The stony matter was slightly fusible, and readily attacked by hydrochloric acid. Scattered through it were rare globules of a brown substance easily isolated by soaking the stone in concentrated hydrochloric acid. When separated, these globules fuse with great difficulty into a black enamel, while the acid exhibits the green tint characteristic of nickel."

Mr. Sœmann then states that the facts relating to these Belgian aerolites suggest observations analogous to those he made with reference to the fall which took place at Ormes in October, 1857. Aerolites have been supposed to arrive with planetary velocity within the earth's sphere of attraction, and he refers to the efforts that have been made to compute the heating effect of an arrestation of their motion by the resistance of our atmosphere, and states that Bunsen and Bronn in the *Neues Jahrbuch der Mineralogie*, 1857, *p.* 265, calculate that the com-

plete arrestation of a mass of iron having such a propulsive force would raise its temperature a million degrees, of which the greater part would be lost by radiation and contact with the air. "It is supposed," he adds, "that a black crust invariably found in aerolites is the effect of fusion resulting from the friction of the air. The strong detonations have been attributed to the explosion of the aerolites in consequence of the great tension resulting from the coldness of their interior, and the heat of their exterior portions." If these theories were accepted, he points out that, it would be necessary to assign to all aerolites having a black glazed surface and experiencing detonation, a velocity sufficient to fuse their external parts. In the case of the aerolites of Tourinnes he affirms that the velocity was very moderate—certainly less than that of cannon-shot. In proof of this he remarks, that when a body advances with great velocity its form cannot be seen, while at Tourinnes those who saw the aerolite agree that it looked like an elongated cylinder.

The second proof of small velocity he derives from the fact that persons who heard the explosions had time to get out of their houses and look at the aerolite before it fell. Thus it could not have advanced as quickly as the sound travelled. In the case of the aerolite of Ormes, a mason assured him that the fragments of the stone bumped from branch to branch of the tree on which they fell. At Tourinnes "the second stone, supposed to have weighed six or seven kilogrammes, struck a young fir about eight centimètres in diameter; and although its trunk was completely flattened by the force of the blow, it was neither cut through nor penetrated by the great projectile, the force of which appears to have been completely deadened, as the stone was found half buried in sandy soil less than a mètre to the right of the tree."

The heat of a portion of one of these aerolites, picked up immediately after its fall, was estimated at 50° Cent.

It will be interesting to see what comments astronomers and physicists will make upon these curious observations.

THE WIND AND ITS DIRECTION.

BY E. J. LOWE, F.R.A.S., F.L.S., ETC.

THE registration of the changes of the wind as marked down by the "Atmospheric Recorder," is known to but few persons. Only one instrument is at work, and this is at the Beeston Observatory. The value of the instrument is so great that it deserves to be described.

The late Mr. Henry Lawson, F.R.S., of Bath, and the late Mr. George Dollond, were the inventors and constructors of this machine.

Sir John Herschel had published a request to all observers to make constant observations for twenty-four hours on four specified days in each year; and Mr. Lawson being an ingenious mechanic and an active observer of the weather, considered that he was bound as a philosopher to assist; he therefore determined to have a machine constructed that should record by mechanical contrivances all the changes that take place in the atmosphere at the time of the occurrence. After expending many hundred pounds, he at last succeeded in producing an instrument that would do the following work with a number of pencils and zero pencils:—

Pencil 1 records the hour on the west edge of the paper.
„ 2 is the zero pencil for rain.
„ 3 records the commencement and termination of every shower, and the amount of rain fallen every minute.
„ 4 is the zero pencil for evaporation.
„ 5 records the amount of evaporation every minute.
„ 6 is the zero pencil for temperature (marking the freezing point).
„ 7 records the temperature of the air every fifteen minutes.
„ 8 is a zero pencil for wind direction, drawing the zero of a west wind.
„ 9 is a zero pencil for wind direction, drawing a north or south wind according as the curve is convex or concave on this line.
„ 10 is a zero pencil for wind direction, drawing the zero of an east wind.
„ 11 records the wind's direction every minute.
„ 12 is the zero pencil for the force of the wind.
„ 13 records the force of the wind in oz. and lb. pressure on the square foot every minute.
„ 14 } are the zero pencils of the hygrometer, the one drawing
„ 15 } the line of *perfect dryness*, the other that of perfect saturation.

Pencil 16 records the hygrometrical state of the air every fifteen minutes.

„ 17 records the amount of atmospheric electricity.

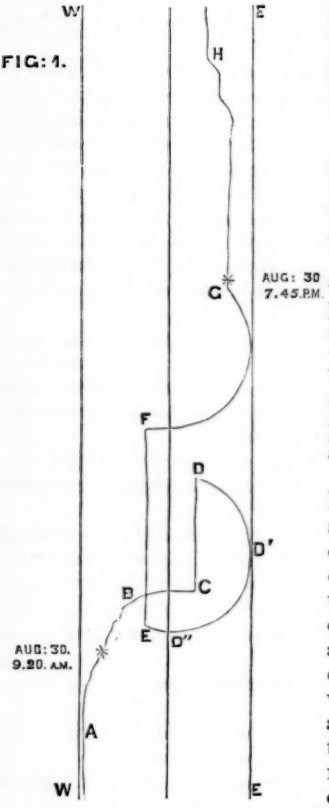
„ 18 } zero pencils from the barometer, the one marking a
„ 19 } zero of 28 inches pressure, and the other one of 31 inches.

„ 20 records the height of the barometer every fifteen minutes.

„ 21 records the hour on the east edge of the paper.

It will thus be seen that twenty-one pencils are constantly employed, and, in fact, doing the work of a whole corps of observers. Our present purpose is not to describe the instrument except as regards the wind-pencils.

FIG: 1.



It is of the greatest importance to have the means of knowing when every change in the wind takes place; and were a dozen instruments like the "Atmospheric Recorder" in action, in as many well-selected places in England, we should speedily know more about the wind and its movements. Waves of air would be detected, and the time when they passed across each observatory accurately recorded.

From this instrument we learn that the wind works in several different ways, at one time *a steady immoveable current* in a certain direction, which can change to any other direction without oscillation; at another, it is *nodding* on a certain point of the compass; whilst, at a third, it *oscillates*, and sometimes violently, so that (as instance) a south wind may be immoveable in south, or it may slightly move 1° or 2° on either side of south, or it may oscillate from S.W. to S.E., or even from W. to E., and still be a south wind.

To understand this correctly we will take several examples, but before doing so, it is requisite to mention that a long piece of drawing paper is placed upon a roller; this passes between two brass cylinders on to a glass table, at the end of which is another roller with weights, a clock drives this paper across the table at the rate of half an inch an hour, and the roller and weights wrap it up after the records have been made. Fig. 1 is an exact copy of the movements of the wind on the 30th of last August, the two stars showing the direction at 9·20 a.m. and 7·45 p.m. The line WW is the zero of a west wind, the line EE that of an east wind, and the line NN that of a north wind, if the curve is *concave*, but south if *convex*. It will be sufficient to say, that if the wind pencil (which writes amongst these three lines) touches the line E, it must be east and so on. The wind on August 30th, 1863, is an example of a stationary wind, although the changes between 10 a.m and 8 p.m. were most extraordinary. The wind had been blowing WNW. where marked A, on reaching the star (*) NW., at B it was NNW., moving in one sweep from B to C, at C it was NNE., in which quarter it remained till the point D was reached, it then veered in one sweep through east (D′) and south (D″) to nearly SSW. (E), remaining in this quarter to F, then sweeping through E. to NE. (G) at 7.40 p.m., remaining for some time in this quarter, and becoming NNE. at H, so that from A to G in the space of twelve hours the wind moved—

WNW. to NNE.	=	90°
NNE. to SSW.	=	180°
SSW. to E.	=	112½°
E. to NE.	=	45°
		427½°

Or 427·5° without a single oscillation.

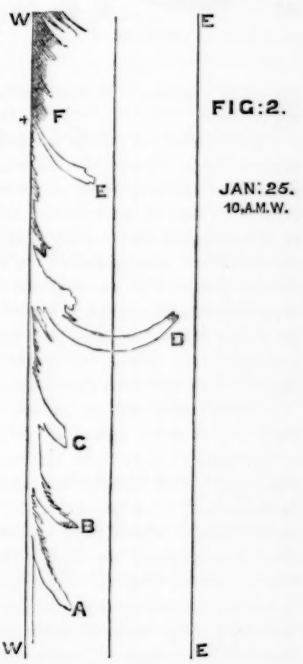


FIG:2.

JAN: 25.
10.A.M.W.

In Fig. 2 we have a different character of wind (the example being on January 25th, 1864), what I have called a *nodding wind*, on WSW., with veerings to SW. at A, B, and C, and a singular change through S. to ESE. at D, and back again in

half an hour, another change at 10 a.m. to SSW., and back again, after which the wind oscillated gently on WSW.

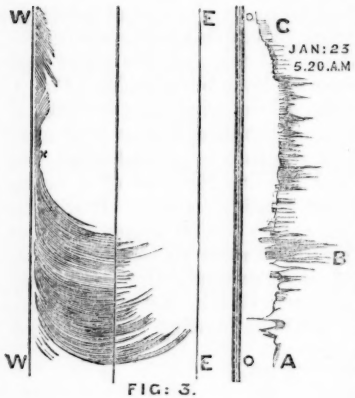


FIG: 3.

In Fig. 3 (January 23rd, 1864) we have an example of an oscillating wind, which was violent at first on S. (the oscillations reaching from SW. to ESE.), then SSW. (the oscillations extending from W to SSE); at 5·20 a.m. suddenly veering to WNW. (with small oscillations) and then to WSW. In this diagram a gale of wind occurred, and the manner of registration is shown in Fig. 3, the line *O O* being the zero pencil line of a calm, and A, B, C the registration of the wind's force on the square foot, the greatest violence of the gale occurring at B, when 7lb. was registered.

The value of such a series of registration is great, and especially so since Mr. James Glaisher has shown that a wind law exists, a law of movement in which in some years the direct movements exceed the retrograde; whilst in other years the retrograde movements predominate, *i.e.* when *direct*, working forward like the hands of a watch, and when *retrograde*, moving in the opposite direction.

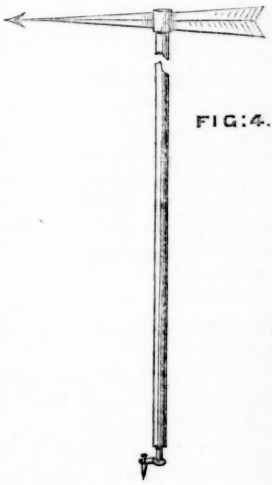


FIG: 4.

The contrivance is so simple that it cannot get out of order, consisting of a simple brass rod, to the upper end of which a wind vane is attached, whilst at the base a pencil on a short arm records all the movements as the rod itself turns round, Fig. 4. This brass rod is taken advantage of for the wind's force; being hollow, a wooden rod extends through it, attached to a force board on the vane; whilst immediately above the registration table a cradle is suspended,

to which is attached a conical cup containing different lead weights, ranging from half an ounce to 36 pounds. According to the force of the wind these weights are raised, and the pencil marks the exact weight lifted up.

The "Atmospheric Recorder" and many other meteorological instruments were presented to me *by Mr. Henry Lawson*, and are now doing me good service at the Beeston Observatory.

CONSTANCY OF SOLAR LIGHT AND HEAT.

BY ALEXANDER S. HERSCHEL, B.A.

Those who admit no waste of power in the different operations of the energies of nature must encounter the difficult question of the maintenance of a constant source of light and heat upon the surface of the sun. The sun constantly delivers to the earth, in heat alone, an energy equal to the hundredth part of that force by which it constantly draws the earth into a spiral path about itself. This is but the two thousand millionth part of the total heat, or energy, which the sun continually develops and dismisses into space; yet the efflux is unabated, and has apparently remained the same from the earliest historic ages, and from the remotest ages of geology, to the present time.

Misled by the almost fabulous scale of this outlay, some have attempted to persuade themselves that a new theory of solar radiation might prove the estimate to be overdrawn. They propose to consider that solar heat, like gravity, is imparted only to surrounding objects, by a species of reciprocation, or by a sympathetic interchange between the sun and other bodies; and that it is the part of surrounding bodies to disperse the solar heat into space under the usual laws of radiation and in the ordinary form of radiant heat: did they not do so, that these bodies and the sun would reach an equilibrium of temperature by an interchange of heat, and would maintain it unabated to the end of time.

This theory, in itself incredible, makes it yet apparent that if a reasonable explanation could be given of the constancy of solar light and heat it would be accepted, by analogy, as a step towards the better understanding of the great law of Newton—that one particle constantly attracts another in proportion to its mass.

The sun as a merely heated body would fall in temperature and lose its light sensibly in the course of a small number of years, or even months. This temperature does not appear greatly to exceed that of the electric arc, but it remains un-

XUM

changed. At such a temperature many, perhaps all, chemical compounds are dissociated into their elementary parts. Were all the elements of the sun dissociated by reason of an uniform prevailing temperature, their gradual recombustion, and exertion of their chemical affinities, would maintain the constant temperature of the sun for a prolonged period of 8000 years. Neither Original heat alone, nor Original heat combined with chemical attraction, are, therefore, sufficient to continue the solar activity for an indefinite time. These two operations may be seen in action together in a fireball with a permanent streak of light. The fragments of the meteor are red in light, and rapidly disappear as their temperature falls and vanishes by radiation. The streak is of immensely higher temperature, and the recombustion of its dissociated vapours maintains the high temperature at a constant value for many seconds, and occasionally for many minutes after the disappearance of the fragments. A continual repetition of meteors would be required to supply the earth with incessant light from such a source, and such a succession of meteors is therefore supposed to occur upon the surface of the sun. It is calculated that a yearly deposit sixty-six feet in depth of solar satellites would actually suffice to maintain the present supply of solar light and heat unchanged: a quantity much too minute to be perceived in less than many thousand years by angular measurements of the sun's diameter.

The light and heat of meteors upon the earth are confined to the highest strata of the atmosphere. It appears that this is equally the case upon the sun, and that the meteoric particles from their minuteness are consumed, and all their elements dissociated at the boundary of the solar atmosphere. Their fiery streaks alone remain. Like steam condensing into water, these maintain their high temperature until all the elements have re-combined and dispersed abroad their latent heat. Such streaks are actually seen upon the sun as straw-like or leaf-like lines, which intersect each other in every conceivable direction. When cooled, the matter must descend as dust or in drop-like pieces upon the surface of the sun. The spots which appear upon the luminous envelope of the sun may arise whenever an aerolitic mass of large dimensions penetrates to the solar surface unconsumed, and with volcanic violence destroys the order of the atmospheric strata where it strikes. The spots are far removed from the solar poles, and therefore near the plane of the ecliptic where the planets have their orbits; but the leaf-like lines are seen over every portion of the sphere of the sun, like fireballs at the surface of the earth. Chemical affinity may thus be said to act the part of a damper and regulator of the solar fires, reserving portions of the heat suddenly imparted to the sun, and again maintaining its uniformity of tempera-

ture, when a cessation of the impulses would otherwise be followed by a waning of its light.

If no illustration can be found in the regular emission of solar light and heat, to the constant exercise of gravitation in every particle of matter, at least it appears more philosophical to approach the unexplored ground by open paths, than to ascribe both these principles of solar heat and gravitation, together, to mysterious agency, on account of their activity alone.

INSANITY AND CRIME.

The attention of the public has been very strongly called by a recent case to the question of insanity and crime, and it may therefore be a convenient opportunity for endeavouring to ascertain a few of the scientific principles by which such investigations should be guided, and jurisprudence controlled. In the first place let us endeavour to limit the inquiry within the bounds of the *knowable*, for it is clearly useless, or even mischievous, to suffer ourselves to be led astray in the performance of practical duties by indulging in speculations which the restricted nature of our faculties must of necessity render uncertain, and incomplete. When any member of our society has committed an offence, we must not expect to be able to measure the actual quantity of his guilt. To do this we should have to ascertain the precise force of the temptation that led him astray, and the precise force of the resistance to the temptation which he might have exhibited had he strongly desired and earnestly willed to do that which was right. Not only should we have to ascertain these facts in relation to the actual state of the individual at the period of the commission of his offence, but we ought to have the whole of his life-history before us, in order that we might discover at what times he had destroyed the just balance of his faculties, by performing acts or acquiring habits that were bad, when it was within his power to have performed and acquired acts and habits that were good. It is quite plain that such an inquiry would far transcend all human powers, and we must therefore confine our researches to a humbler sphere, and go to the work with a consciousness that our most careful judgments are likely to be wrong.

Practically, our proceedings must be limited to two inquiries: firstly, whether an accused person did really commit the act which our law declares to be an offence; secondly, whether he was labouring under *physical* conditions that detracted wholly, *or to a great extent*, from that normal position of responsibility which we feel justified in assigning to human

beings. No one has ever pretended that all men are responsible in equal degree for their actions. The divine, the moralist, and the popular voice, all exclaim, concerning one offender, that his offence is aggravated by his position and circumstances; while they say of another, that his error admitted of much excuse. Morally, the duty of each is to make the best use he can of the faculties assigned to him, and unless we could prove that all men were born with equally good organizations and lived under equally beneficial conditions, we could not establish the theory that all were equally worthy of praise when they did right, or equally deserving of blame when they did wrong. But while we are compelled to recognize responsibility as existing in different degrees amongst persons whom we have no right to consider insane, and also among those to whom that epithet may be applied, our jurisprudence can only take cognizance of differences that are obvious and clear. There is a sense in which all sane criminals may be considered insane, for serious crime is seldom committed until habits have been formed, by which animal propensities have been encouraged to gain the upper hand. Such cases are, however, widely distinguished from actual cerebral disease, and it is the determination of the existence or nonexistence of disease that imposes upon our tribunals one of their hardest tasks. If an accused person has the obviously defective brain of an idiot, and his mental manifestations have always corresponded with the idiotic type, no difficulty is felt. The trouble begins when an individual has been deemed sane up to commission of a crime, and we have to take the crime itself, with all its attendant circumstances, as part of the evidence by which insanity may be demonstrated.

The ideas of insanity enshrined in the decisions and *dicta* of our most eminent judges are so obviously absurd that it is astonishing they could ever have been tolerated in any society pretending to civilization. In Bellingham's case, Lord Mansfield told the jury, that before the prisoner could be acquitted on the plea of insanity, "it must be proved beyond all doubt that he did not consider murder was a crime against the laws of God and nature;" and in McNaughten's case, when the House of Lords propounded certain questions to the judges, Mr. Justice Maule replied, "that to render a person irresponsible for crime on account of unsoundness of mind, the unsoundness of mind should, according to the law, as it has long been understood and held, be such as to render him incapable of knowing right from wrong." Chief Justice Tindal brought *legal insanity* to a climax by informing their lordships that "we" (the judges) "are of opinion, that notwithstanding the party accused did the act complained of, with a view, under the influ-

ence of insane delusion, of redressing or avenging some supposed grievance, or injury, or of producing some public benefit, he is nevertheless punishable, according to the nature of the crime committed, if he knew at the time of committing such crime he was acting contrary to law!"*

Thus the English law decides the question of responsibility upon singularly unscientific grounds. Its test is totally fallacious, and it errs moreover, by a false assumption, upon which Dr. Bucknill thus comments:—"It is the system of the English law to allow no degrees of responsibility. A criminal is either responsible or he is irresponsible: there are but two classes, in one of which room must be made for every one who commits an offence. In nature we find no such sharply defined classification."† So far indeed from absolute irresponsibility being a result of insanity, it is scarcely, if ever, the case; and Langerman, cited by Dr. Bucknill, observes, "that even in the highest degree of insanity there still remains a trace of moral discrimination, with which we may connect the train of the patient's ideas."

In modern lunatic asylums a prominent part of the remedial treatment consists in making the patients feel that they ought, and can, comply with the wholesome regulations arranged for their benefit. The directors of such establishments lessen their inducements to act foolishly by removing incentives thereto, and they strengthen their resisting power by calling appropriate faculties into play. Long ago Haslam cited with approbation the following passage from Dr. Cox, who said:—"The maniacal patient, however torpid, must be roused; or, on the contrary, when an opposite state obtains, extreme sensibility and impatience of powerful impressions, there may be much expected from placing the patient in an airy room, surrounded with flowers breathing odours, the walls and furniture coloured green, and the air agitated by the softest harmony."‡ The use of such attendant circumstances was to bring the patient's organism to a more balanced state. Without the rousing or the soothing influences, the disease controlled him; under them, a condition of approximate self-guidance and responsibility was attained. The experience of the Idiot Asylum at Earlswood has demonstrated that even those deeply afflicted and imperfectly organized beings who are consigned to its care, may be made partially responsible, because, under certain conditions, they became invested with a certain portion of self-control.

We have said that in criminal cases, before the plea of

* We have cited these cases from *Roscoe's Digest*, edited by Granger.

† *Unsoundness of Mind in Relation to Criminal Acts*, by John Charles Bucknill, M.D., London. Highley, 1854. P. 115.

‡ *Haslam on Madness.* Second edition, p. 341.

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insanity can be admitted, a large deficiency of self-control, resulting from disease, should either be proved, or shown to be reasonably inferred. In the celebrated case of Henriette Cornier, described at length by Georget,* a mild, lively girl, remarkably fond of children, became silent and melancholy in June, 1825, and finally sank into a kind of stupor. In September she attempted suicide. In October she entered the service of Madame Fournier, who could not dispel her dejection, and the girl would only talk of her misfortunes in losing her parents at an early age, and being ill-treated by a guardian. On the 4th of November she persuaded a Madame Belon to allow her to take her child—a little girl, for whom she had always evinced great fondness—for a walk, and having obtained possession of it, she cut its head off and threw it into the street, in order that the passengers might be attracted, and know she had done the deed. She stated that the idea had taken possession of her mind, and she was determined to do it. In such cases there is no difficulty in arguing the existence of insanity from the proof that the character of the patient had changed in a mode quite contrary to the known progress of *moral* depravity; but a commission of distinguished French physicians could not obtain proof of mental derangement by examining the girl after the offence. A second commission made a similar report, but added that their judgment could not be considered final if it could be proved that long before the 4th of November her character and habits had changed. Finally a jury found her guilty of "homicide without premeditation," and she was sentenced to hard labour for life. In this case an injustice was plainly done, because the court neglected to take sufficient cognizance of the conditions that preceded the offence; and it shows the necessity of inquiring into the previous life of an offender before rejecting the plea that he is insane.

In many instances in which the plea of insanity is set up, the offence is one likely to spring from moral depravity. It appears to have been instigated by motives likely to rule the conduct of wicked men, and it is in conformity with the general behaviour of the offender. Under such circumstances the plea of insanity is usually rejected, even though it can be shown that the prisoner's ideas on many subjects are very absurd. But extreme cases occur, in which many people would be disposed to accept the theory of insanity, although no disease could be shown. Pinel records a case,† in which the only son of a weak, indulgent mother was encouraged in the gratification of caprice and passion. The result was an ungovernable disposition, that grew with his years. He quarrelled savagely

* It is cited by Ray, *Jurisprudence and Insanity*, p. 198.
† Cited by Ray, p. 159.

upon the most trifling cause, assaulted his adversaries with fury, and would instantly kill any animal that offended him. When he came of age he was found competent to manage his estate, and was in some instances benevolent, but continually involved himself in ferocious strife, and finally killed a woman who used offensive language to him, by throwing her down a well. Similar cases, though milder in degree, often occur; and it would seem most consonant with reason to hold them as exhibitions of highly cultivated depravity, unless they can be accounted for by very plain and positive proof of disease. The paroxysms of rage exhibited by such persons differ widely from such instances as that of a lady who, up to the age of forty-three, was never known to manifest a passionate disposition, but, after the birth of her last child, was subject to overpowering fits of rage, excited by the most trifling causes.*

If good ground appears for believing that cerebral disease exists, it would seem proper that it should be held as very likely to have destroyed responsibility to a greater or less extent, even though its only traceable results were not obviously connected with the crime. Thus, if the disease was only known to have led to the delusion that an individual was made of glass, and his offence was forgery, it would be difficult to avoid the belief that the offender's self-control *might* have been lessened by the disorder, although we could not exactly tell how. In such cases, justice would object to an irreversible sentence like the death penalty formerly enacted for forgery in this country, or to a cruel punishment; but it would not necessarily object to a penal discipline directed towards the amendment of the patient, and accompanied by what medical treatment his case required.

The question will be asked, Would you then punish men who are not sane? The reply is necessarily a little complex. In the first place, no man, however sane, ought to be punished *brutally*, and if we omit the consideration of capital punishment, it will be universally conceded that no man ought to be compelled to undergo a secondary punishment that is not calculated, directly or indirectly, to promote his reformation.

No scientific man would deny Dr. Bucknill's statement concerning degrees of responsibility, and few would demur to the doctrine of a quotation which he makes from the fifth report of the Inspectors of Lunatic Asylums in Ireland, in which, after protesting against a morbid disposition to render lunacy the protector of crime, they say, "If there are extenuating circumstances connected with the psychological condition of the accused, they are legitimate subjects to be considered in meting out the after punishment, but certainly not in the first instance,

* *Obscure Diseases of Mind and Brain*, first edit., p. 179.

for an unqualified acquittal." It is not, however, a question of *punishment* only, but of the treatment most likely to amend its subject.

Unreasonable opinions should not too readily be allowed to lead to the inference of insanity as a disease; and certainly not when those opinions take a form quite consonant with the motives a criminal would be likely to cherish. Suppose after a murder, a man should say that he believed all people were blind instruments of fate, and it should be found that he had for many years represented himself as compelled to do whatever acts he performed. There would in this, be no indication of insanity, intellectual or moral. But if it could be shown that, after leading a life of average self-control, he had from a particular date believed himself impelled by a power he could not resist, there would at any rate appear very strong ground for inquiry whether he had fallen under the thraldom of a disease.

Judges have shown no disinclination to believe that disease may cause intellectual insanity; but the only form of moral insanity they have been willing to admit, is that non-existent kind, in which persons capable of cleverly concocted crimes are supposed incapable of knowing what the law deems right and wrong. Such errors show how exclusively professional tendencies may warp the mind, so that in particular directions it cannot see the plainest truth. If the brain be admitted to be the organ of animal propensities, moral faculties, and intellectual faculties, it is illogical to deny that its disorder may lead to an excess or a deficiency of action in any one of these departments, and from thence may arise a degree and kind of insanity, by which moral responsibility may be lessened to a greater or less extent. A state of general bodily health requires that there shall be a certain proportion between the rate at which work is done by the several organs of which our frame is composed. Too much vitality in the lungs or liver would disturb the condition of health, even though those organs did nothing wrong in kind. Thus looking to the body as a *whole*, it may be diseased simply by processes of supply and waste going on too fast or too slow in particular parts.

Physiologists have as yet failed to explain how the brain manages to do its multifarious work; but without presuming to map it out into distinct organs, we may believe that its healthy action as a *whole* requires an exact regulation of the rate at which its different parts undergo change, and thus there may be cerebral disorder without any obvious exhibition of inflammation, or other violent action. Microscopic investigation may ultimately throw much light upon these questions; but however obscure the nature of insanity may be, we must never

forget that we must treat it as belonging to *physical* inquiry; as *mind*, apart from organization, is utterly beyond the *medical* art, and is subject to higher powers than sit in earthly courts.

If the preceding facts and arguments are appreciated, we shall arrive at a few practical results. In the first place, we shall desire a change of our law in conformity with common sense; nor shall be diverted from this demand by a citation of a few decisions not quite so barbarous as those to which we have directed attention. We shall require that the law shall take cognizance of any form of insanity that really exists, and that it shall admit the existence of degrees of responsibility.

In the next place, we should demand that the investigation and decision of an alleged case of insanity, being a highly difficult, and often complicated scientific process, should not be left to the accidental influence which highly-paid witnesses may have upon the minds of an imperfectly educated jury; but that, on the contrary, it should be an inquiry carefully conducted, by men who have no personal interest in its result, and who should be empowered to carry it as far back into the previous life of the accused as may be needful to arrive at a satisfactory conclusion. Thirdly, instances will occur in which it may not be practicable to determine the final disposition of the supposed criminal lunatic, until he has been for a considerable time under constant supervision, by which his actual state may be disclosed.

Lastly, we shall perceive that criminal lunatics will not form a class all of one sort. Some will be sincere objects of affectionate pity, while others, being more or less responsible, will deserve actual punishment as well as medical care.

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CLUSTERS AND NEBULÆ.—DOUBLE STARS.—OCCULTATIONS.

BY THE REV. T. W. WEBB, M.A., F.R.A.S.

When Sirius, now so magnificent an object in our southern sky, is on the meridian, about 4° below him the eye will just catch a feeble, cloudy patch; this is—

15. 41 M (*Canis Majoris*). A beautiful, brilliant, and widely-extended group of 8 mag. and smaller stars; one of the brightest near the centre I found to be of an orange or ruddy hue; as has also been noted by H (No. 411). A remark of this great observer with respect to irregular clusters, that "it is no uncommon thing to find a very red star much brighter than the rest occupying a conspicuous situation in them," seems to be to a certain degree exemplified here. Some law is probably concerned in this arrangement, but of a nature to us utterly incomprehensible.

Sirius is nearly in a line between two smaller attendants, each at a distance of several degrees. The larger one lying *p*, a little *s*, is β *Canis Majoris*, 2 mag.; the other *f*, a little *n*, is γ, 4 mag. A line from Sirius to the latter star, carried on through the galaxy nearly twice as far again, and turned a little downward, will encounter a suspicious-looking district, of an indistinct, *clustery* aspect. This, the finder will turn into a succession of objects arranged in an irregular, and, on the whole, horizontal direction: a wide pair precedes; then comes a bright group visible to the naked eye; a much feebler nebula follows, a little *s*, with a star lying *s p*; then another pair less wide than the first. Each of these will repay our attention. We begin with the most conspicuous, the bright cluster. This is—

16. 38 $\frac{H}{3}$ VIII (*Argûs*). A very splendid field of large and small stars, as Smyth well describes it, which should be viewed with a low magnifier: in the midst of it we shall at once recognize a very neat pair, whose data, according to him, are 8″, 303°·8, 7½ and 8, both bright bluish white. A little way *p* lies a bright star, about 6 mag., attended by a minute *comes n f*. This is now the *lucida* of the assemblage, although H., who numbers the cluster 459, does not mention it, and gives precedency to the double star. About ½° *p* lies a 5 mag. star, the more southerly of the wide pair which leads the whole region in the finder: it is worthy of notice from its fine fiery orange hue. The other smaller one, *n p*, seems greenish, perhaps from contrast. To gain an idea of the grandeur of the galaxy, we should sweep round the outskirts of this cluster, especially in a *n f* direction. "Lift up your eyes on high, and behold who hath

created these things, that bringeth out their host by number: He calleth them all by names, by the greatness of his might, for that He is strong in power, not one faileth." (Isaiah xl. 26.)

The next object in the district follows, a little *s*, looking nebulous in the finder. It is—

17. 46 M (*Argûs*). Described by Smyth as a noble assemblage of stars from 8 to 13 mag. This very beautiful cluster, of which the average seems about 10 mag., is nearly 30′ in diameter, and requires a large field. I have not succeeded in detecting a planetary nebula, which Smyth calls extremely faint, among the larger stars on its N. verge.

The star mentioned as standing *s p* from this cluster in the finder is of a fine orange colour. While examining this, or the previously-mentioned fiery star *p* 38 H VIII, with a power of 64, Feb. 8, 1864, I found it so doubled for a few seconds by irregular refraction, that at the moment I believed it really was a close pair. (See Int. Obs., October, 1863, p. 194, for a detailed account of a similar illusion.)

The last object in this interesting region, a wide double star in the finder, is referred to the continuation of our Double Star List.

In the Intellectual Observer for May, 1862, at p. 277, are directions for finding the head of *Hydra*. Between this region and the one which we have just been exploring, but nearer to the former, and bearing a little to the S., is a star, the most conspicuous in its neighbourhood, which the finder represents as three in a line. From the absurdly perplexing way in which the outlines of the constellations have been arranged, the central and brightest star is given as 30 *Monocerotis*, while it is flanked by 1 and 2 *Hydræ*. We have, however, nothing to do with this ill-named group, excepting as a pointer to a cluster which lies *p*, a little *s*, at a distance of about 3°, and which is so extensive that it will be easily recognized as a faint cloud in the finder. Its synonym is—

18. 22 H VI (*Monocerotis*). Smyth has termed this a splendid group in a rich region containing several small pairs. Its components, chiefly about 8 mag., are condensed in the centre into a lengthened patch of an irregular triangular or arrow-headed form. H., whose No. 496 it is, says that the stars are from the 9·10 to the 13 mag., and none below; "but the whole ground of the sky on which it stands is singularly dotted over with infinitely minute points;" invisible, of course, in any ordinary telescope.

DOUBLE STARS.

Our researches among the nebulæ enable us to add two more pairs to our list. The first is mentioned under No. 17

of the preceding catalogue, where a wide double star is spoken of as bringing up the rear of a group of interesting objects. The brighter of the two is 4 *Argûs*, a single yellowish 6 mag. star; the other will be easily decompounded into a beautiful pair:—

121. 2 *Argus*. 16″·8, 338°·8, 7 and 7½. Silvery white and pale white, 1836·2. I thought the smaller star bluish, 1851·19, 1864·1. This fine object is supposed to be stationary.

122. About 1½° to the S., a wide 7 mag. pair, not mentioned in the Bedford catalogue, is worthy of notice from the striking similarity of its components in size and hue—a deep orange. There can be no faith whatever in appearances, if these two peculiar looking individuals, insulated from any near neighbours, though projected accidentally as it seems upon a rich background in the distance, are not physically connected. Their aspect at once as much bespeaks their binary character as does that of 61 *Cygni*, and there is great probability that an investigation into their parallax and proper motion, as well as their distance and angle, would lead to an interesting result. Their situation, however, commends them preferably to the notice of southern observers.

OCCULTATIONS.

March 18. A^1 Cancri, 6 mag., will disappear at 6h. 58m., and re-appear at 7h. 57m. A^2 Cancri, a similar star, will follow it at 9h. 44m., and 11h. 4m. respectively.—19th. ω Leonis will be hidden from 6h. 11m. till 7h. 28m. See the remarks on the occultation of this star in INT. OBS., Dec. 1863, p. 352. The present is a more favourable opportunity for this curious observation, as the disappearance takes place at the dark limb; the position of the limb, compared with the position-angle of the two stars, seems also well adapted for a successive extinction of the light of each component.—27th. ω^1 Scorpii, 4½ mag., will disappear at 12h. 3m., and will remain invisible for 1h. 2m.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

MANCHESTER PHILOSOPHICAL SOCIETY.—*Jan.* 12.

On the Amount of Carbonic Acid existing in the Air of Manchester.—Mr. Roscoe related the results of numerous experiments made to ascertain the amount of carbonic acid existing in the air in and around Manchester. He found the maximum quantity on a foggy winter day, January 7, 1864, when the amount reached 5·6 vols. per 10,000 of air; the minimum amount, on Feb. 19, 1863, being 2·8 vols. per 10,000 of air; the mean of numerous experiments in the centre of the town giving 3·92 per 10,000, that of London being 3·7. Continuous rain was found to lower the amount from 4·8 to 3·3 volumes per 10,000.

These results show that under no circumstances does the amount of carbonic acid rise to 6 vols. per 10,000 of air, and that the mean quantity, nearly 3·92, closely agrees with that which is generally assumed to be the amount—namely, 4 vols.—this being the average, as obtained by Saussure's well-known investigations.

ETHNOLOGICAL SOCIETY.—*Jan.* 26, *and Feb.* 9.

The Varieties of Man in the Indian Archipelago.—Mr. Wallace read a valuable paper on this subject. He stated the animals of Borneo, Sumatra, and Java to correspond more or less closely with those of Asia; whilst the animals of New Guinea and the adjacent islands confirm the idea of their having been once connected with Australia. The two human races are as strongly marked in their diversity as the animals, Malays inhabiting the western and Papuans the eastern group.

Mr. Wallace accounted for the wide spread of the Oceanic race of the Polynesian Islands, by regarding these islands as being relics of a continent formerly existing in the Pacific, and that the present Polynesians are the descendants of the inhabitants of a continent now sunk beneath the ocean—a theory which is supported by numerous facts, both geological and zoological.

On the Ethnology of Australia, by M. A. Oldfield.—The author considered the New Hollanders to be mainly of Malay descent, which people, he supposes, colonized the northern shores of Australia, and their descendants to have spread lower eastward, over the continent, following, to a great extent, the lines marking the distribution of edible plants. The familiar customs of the various tribes evince a community of origin; but, as the migrations have been irregular, the migratory bands have crossed each other's lines, leaving their traces at the points of transit. That Australia was inhabited prior to its colonization by the Alfouras, seems probable, from the existence of relics of a civilization far higher than can be claimed

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by any tribes of the Malay family. These remains of an extinct civilization consist chiefly of picture-caves and sculptured rocks, works which the present occupants of the soil, far from claiming as their own, ascribe to diabolical agency. As the features and dresses of the figures represented are such as no untutored savage could possibly conceive, and the tools and pigments used are unknown to the existing race, the only just inference we can draw from these facts is, that some more civilized people has been destroyed by the black man; or, possibly, in some instances, the two races have blended, a supposition that would enable us in some measure to account for diversities of characteristics found to exist in various localities. The anomalies for which we thus seek to account exist chiefly among the inland tribes, in which we occasionally meet with physiognomies departing widely from the Australian type; and, to reconcile the discrepancies, we are driven to suppose that the fact is owing to a mixture of the blood of a pristine race with that of the Alfoura; for, had this blending of races been due to the migration of strangers from the sea-board, traces of their presence would be equally perceptible along the lines of their journeyings. On the western and northern coasts, we find the greatest departures from the normal type; and this, doubtless, is owing to the advent of strangers among them: those shores bordering on much-frequented seas being more likely to have been visited by such than either the south or east coasts, which were, perhaps, never visited until European enterprise led the white man to them. One of the principal causes of the reduction of the aboriginal population is the scarcity of the larger kinds of game, consequent on the introduction of cattle and sheep into their country; for the continual tending of the flocks and herds, the frequent driving of them from place to place, but, above all, the constant passage of the stock-drivers, and the wanton havoc of the Europeans, all concur to scare the game, and eventually to drive it beyond the limits of the space assigned to the tribe in whose country these settlers have taken up their abodes; added to which, as such settlements are located in the most fertile parts, from which the natives draw the chief portion of their vegetable diet, it very soon happens that the aborigines find a scarcity of food; and, as the territorial boundaries of each tribe are well defined, they cannot retreat before the white invader; for to pass beyond their own limits would be to expose themselves to the hostility of some other tribe. After suffering hunger for a time, the natives are unable to resist the temptation of a feast on the cattle of the settlers; and, to avenge this act, an indiscriminate slaughter has too often been the policy of the European.

ROYAL MEDICAL AND CHIRURGICAL SOCIETY.—*Jan.* 27.

Entozoa in the Human Blood.—The Secretary read an extremely interesting paper by Dr. John Harley, of King's College Hospital, on a malady (hæmaturia) produced by a species of *Distoma* at the Cape of Good Hope and at the Mauritius. Dr. Harley, from an

examination of the parasite's eggs and embryos (obtained from his own and other patients) was led to believe that they were referable to a new kind of fluke, which he proposed to call *Distoma capense*.

Dr. Cobbold remarked that no person who had previously familiarized himself with the appearances presented by the eggs of the various distomes could doubt for a moment that Dr. John Harley's illustrations represented the ova of the so-called *Distoma hæmatobium*. In short, the symptoms, pathological products, eggs, and embryos described by Dr. Harley, all tended to show that this hæmaturia of the Cape was identical with the well-known Egyptian malady. Dr. Harley's discovery was, however, a most important one in relation to the geographical distribution and prevalence of entozootic diseases; for the author had now demonstrated, in a most satisfactory and able manner, that the helminthiasis in question was not confined to Egypt, as had hitherto been supposed, but was more or less prevalent in Southern Africa and in the Mauritius. Speaking zoologically, this parasite was not a true distome, as it represented the type of a distinct genus, to which Diesing, of Vienna, gave the name of *Gynœcophorus;* Weinland, of Frankfort, had called *Schistosoma;* Moquin-Tandon had denominated *Thecosoma;* and himself had previously entitled *Bilharzia*, after the name of the original discoverer, Dr. Bilharz, of Cairo. He (Dr. Cobbold) had discovered this so-called *Distoma hæmatobium* in the portal blood of an African monkey (*Cercopithecus fuliginosus*) six months before Diesing had communicated his paper to the Vienna Academy, and, therefore, he hoped Dr. Harley (in concert with Weinland and others) would retain the generic name *Bilharzia*, which had the priority. At all events, this was not a new species of fluke, and, therefore, the name *Distoma capense* could not stand. But Dr. Harley's discovery was none the less important on this account. It was quite clear to him (Dr. Cobbold) that our fellow men at the Cape, in the Mauritius, on the banks of the Nile, and also, if you please, our friends, the monkeys, obtained this parasite by swallowing the "intermediate bearers" of the Bilharzia. These "bearers" or "hosts" were small mollusks or aquatic animals, inhabiting the African rivers. They contained the higher larval states of this parasite, the larvæ being introduced into the human body by drinking the African waters unfiltered.

ENTOMOLOGICAL SOCIETY.—*Feb.* 1.

Probable New Source of Silk.—Professor Westwood showed samples of a peculiar silk forwarded from St. Salvador, South America, said to be produced by larva feeding on a native species of oak (Quercus). The silk, which is produced in flat layers, and not in cocoons, is said to be of good quality, and to be capable, after carding, of being used in the arts.

Mr. F. Smith showed a curious collection of wasps' nests, in every stage of progress, from their first commencement to their completion. All of these had been constructed under the direct superintendence of Mr. Stone, who has so far succeeded in domesticating wasps as to be able to induce them to construct their nests in any situation that he wishes.

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GEOLOGICAL SOCIETY.—*Feb.* 3 *and Feb.* 19.

The Permian Rocks of the North-West of England.—Sir R. I. Murchison and Professor R. Harkness communicated a paper on the Permian group, in which they propounded a new view of their composition; and, by the consequent re-arrangement of the rocks involved in this change in classification, they were enabled to place the Permian strata of Great Britain in direct correlation with those of the continent of Europe. This new feature in British classification is the assignment of a large amount of red sandstone in the north-western counties to the Permian period, and its removal from the New Red Sandstone, or Trias-formation, to which they have hitherto been assigned in all geological maps. The authors showed that these red sandstones are closely and conformably united with the Magnesian Limestone, or its equivalent, and form the natural upper limit of the Palæozoic deposits. They thus affirmed that a tripartite arrangement of the Permian rocks holds good in Westmoreland, Cumberland, and Lancashire, and that the three subdivisions are correlative with those formerly shown by Sir R. I. Murchison to exist in the Permian deposits of Germany and Russia.

The difference in lithological details of the Permian rocks of the North-West of England from those on the opposite flank of the Pennine chain was next adverted to; and it was observed that, with so vast a dissimilarity in their lithological development in England, we need not be surprised at finding still greater diversities in these protæan deposits, when followed into Germany and Russia.

The discovery, by Professor Harkness, in the central member of this siliceous group in Westmoreland, of numerous fossil plants identical with the species of the Kupfer Schiefer in Germany, and in the Marl-slate of the Magnesian Limestone of Durham, was given as a strong proof of the correctness of the authors' conclusions.

On the 19th Feb. Professor Ramsay delivered an annual address of unusual interest and importance. The subject was a continuation of that of last year, and the learned Professor went into an elaborate investigation of the evidence that great breaks existed in the biological and stratigraphical record presented by the secondary formations in this and other countries. When the address is published it will, no doubt, receive further notice in the Intellectual Observer; and all that our present space and opportunity permits is to say that an investigation of all the known facts concerning the secondary, or Mesozoic, strata, confirms the views expressed by Professor Ramsay, and coupled by the leading geologists, with reference to the Palæozoic rocks,—namely, the incompleteness of the record, and the strong probability that the whole series of changes in the life of the globe have been brought about by the very slow and gradual action of causes operating through enormous periods of time. Professor Ramsay laid before the Society carefully prepared tables, to show the proportion of species that can be traced upwards and downwards from particular secondary formations. These tables show the changes, of which known rocks furnish the records, to be more gradual than has generally been supposed; and, if we make

allowance for the loss or non-discovery of so many pages in the great Stone Book, the idea of a series of alternate creations and destructions must give place, to make way for a continuous picture of descent with modifications, and a replacement of species by causes analogous to those which affect the fauna of our own times.

NOTES AND MEMORANDA.

NEW FACTS IN FERMENTATION.—M. A. Béchamp states in *Comptes Rendus* that if the must of grapes of different kinds is filtered, the ordinary alcoholic ferment (yeast) only appears in it; but, if not filtered, thread-shaped ferments make their appearance also, and occur largely with free access of air. The fermentation of filtered grape juice effected by yeast only, yields a wine that differs considerably from that of unfiltered grape juice fermented in the ordinary way. He cannot state exactly what part is performed by the filiform (vibrio-like?) ferments, but does not find that they materially augment the quantity of acetic acid in the wine.

SHOOTING-STARS IN THE TWO HEMISPHERES.—M. Poey, in a paper communicated to the French Academy on the Shooting-Stars he had observed at Havannah, states that the number of meteors seen in the Northern Hemisphere is nearly double that of those seen in the Southern; and that, while in the Northern the maximum number is seen between one and two o'clock, in the Southern the greater part are seen between two and three.

SPONTANEOUS GENERATION COMMITTEE.—At the sitting of the French Academy on January 4th, M. Pasteur stated that Messrs. Pouchet and Joly denied his assertion, "that it was always possible to take from any place a noticeable, but limited quantity of air, which had not undergone any modification, chemical or mechanical, and which was, nevertheless, unfit to cause any alteration in an eminently putrescible liquid." MM. Joly and Musset declared that if, under such circumstances a single vessel remained unaltered, they would acknowledge their defeat. M. Pouchet said, "I affirm that, from whatever part of the globe I take a cubic decimetre of air, when I place it in contact with a fermentable liquor enclosed in a hermetically sealed vessel, it is always filled with living organisms." All the parties were willing to repeat their experiments before a Commission named by the Academy, and accordingly Messrs. Flourens, Dumas, Brongniart, Milne Edwards, and Balard were nominated for the purpose.

ANILINE YELLOW AND ANILINE BLUE.—Professor Hoffman has communicated to the Royal Society his observations on a yellow substance obtained by Mr. Nicholson from a resinous substance left in the preparation of rosaniline. Professor Hoffman calls this material *chrysaniline*, and states that it is a finely-divided yellow powder, like fresh precipitated chromate of lead, uncrystalline, scarcely soluble in water, easily so in alcohol and ether. It constitutes an organic base, represented by the formula $C_{20}H_{17}N_3$.

To form *Aniline blue*, rosaniline salts are heated at a high temperature with excess of aniline, or rosaniline is so heated with salts of aniline. The transition was first observed by MM. Gerard and DeLaire, and has become the foundation of a new branch of industry.

THE CLIMBING ANABAS.—Some doubt having been thrown on the climbing properties of this curious fish (*Anabas scandens*), Captain Jesse Mitchell, of the Madras Government Central Museum, states in the *Annals Nat. Hist.* that his assistant, Mr. Rungasaway Moodeliar, has seen it climb palmyra trees growing by the side of a tank or pool. The fish climbs by means of its opercula, which move unlike those of other fish. It crawls up the tree sideways to the height of five or seven feet, and then drops down.

ILLUSTRATION OF NEGATIVE EVIDENCE.—Many disputes in geology are founded upon the generally unwarrantable assumption that certain animals or

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plants could never have existed, because their remains have not been found. It is, therefore, interesting to note a modern instance, in which naturalists are without that kind of proof, furnished by a specimen, of the existence of an enormous animal, apparently not uncommon. Dr. Gray, speaking of the Physetes, or Black fish of the whalers, states in the *Annals Nat. Hist.*, "there is not a bone, nor even a fragment of a bone, nor any part which can be proved to have belonged to a specimen of this gigantic animal to be seen in any museum in Europe. This is the more remarkable, as the animal grows to the length of more than fifty feet, is mentioned under the name of the Black fish in almost all whaling voyages, and two specimens of it were examined by Sibbold, having occurred on the coast of Scotland."

The Nile in Early Ages.—The *Quarterly Journal of the Geological Society*, No. 77, contains an important paper by Dr. Leith Adams, who has been collecting fresh-water shells in the Nile Valley at considerable elevations above the present river level in flood seasons. The conclusions deduced from his observations are "that there is reason to infer that the Nile in early ages was a rapid river, and that the force of the stream has been steadily declining; at least, since the upheaval (?) of the valley ceased." Dr. Adams adds that Mr. Rhind's observations tend to show that "the change has been scarcely perceptible within the long historical periods furnished by the records, excepting on certain points caused by a change in the direction of the river's force."

Artificial Rainbow.—M. J. Duboscq has contrived for the French theatre a method of imitating the rainbow, of which *Cosmos* speaks very highly. He employs an electric light, obtained with the aid of 100 Bunsen elements. The first lenses of his optical apparatus render the rays from this source parallel, and transmit them through a rainbow-shaped hole in a screen to a double convex lens of very short focus, from which they pass to a prism, and emerge with sufficient divergence to make an effective rainbow on a screen about six yards off. This rainbow is said to be brilliant even when the whole scene is lit up.

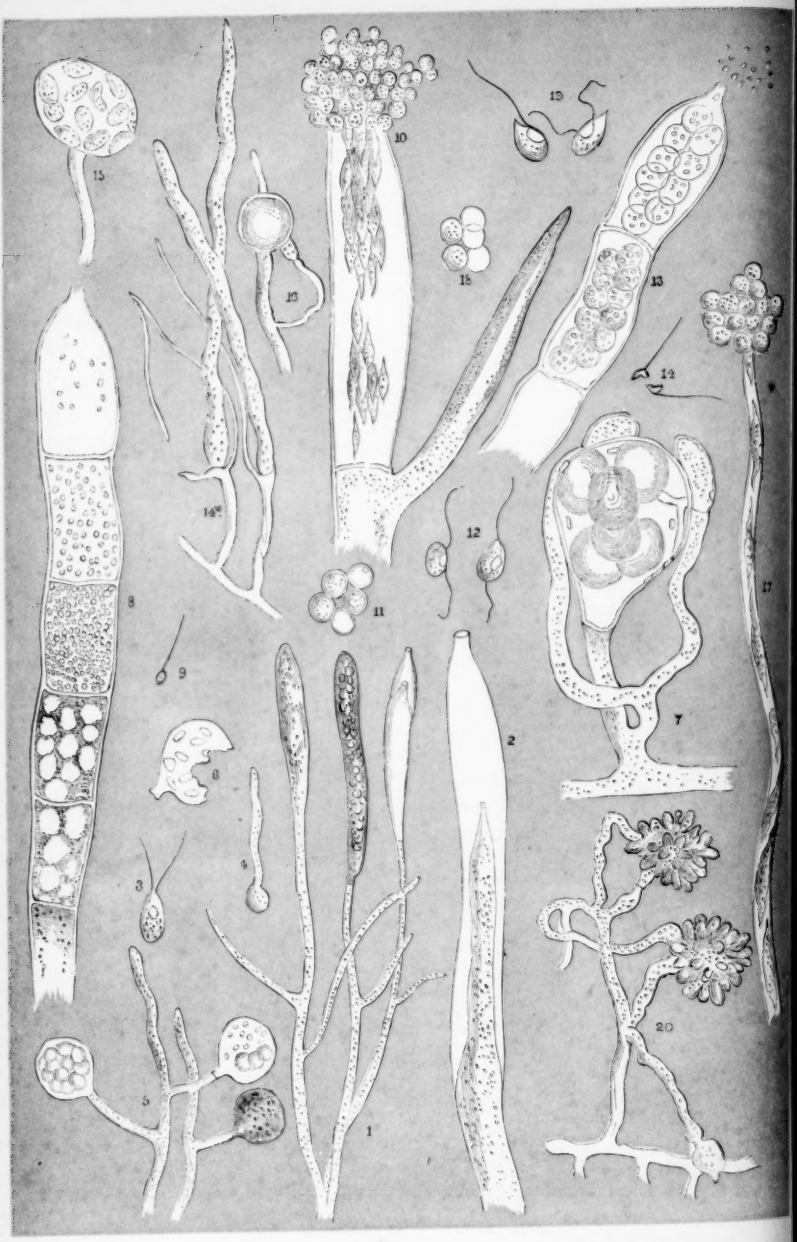
An "Aerial Navigation Society."—A society under this title has been constituted in Paris, to assist the experiments of M. Nadar, and promote atmospheric travelling.

Electrical Light at Cape de la Héve.—The French government has maintained an electrical illumination at this lighthouse, which is near Havre, since 26th December.

Industrial Education of Spiders.—M. Duchesne Thoureau has forwarded to *Cosmos* a specimen of a sort of felt produced by spiders in confinement, and he states that a sufficient number of these creatures placed under conditions of domestication, which he does not explain, will make soft, warm carpets of any size! The editor of *Cosmos* says that the specimen of spider manufacture sent to him is like German tinder in appearance.

Preservation of Meat.—M. Pagliuri has sent a note to the French Academy on his method of preserving meat. He washes it over with a liquid composed of alum, benzoin, and water, this leaves a film of a protecting substance, which he states permits evaporation to go on, but prevents the access of the ferments of putrefaction. Specimens of the preserved meat were exhibited, but they are said not to have presented a very enticing appearance.

Injection of Oxygen into Veins.—M. M. Demarquay and Lecompte have shewn that considerable quantities of oxygen may be thrown into the *vena cava* below the liver, or into the *vena porta*, without killing an animal and without changing the colour of venous blood.—*Comptes Rendus, No.* 4. 1864.



EGG PARASITES.

1, 2, 3, 4, 5, 6, Saprolegnia ferax. 7, S. monoica. 8, 9, S. dioica.
10, 11, 12, Achlya prolifera. 13, 14, A. dioica. 14,* 15, 16, Pythium monospermum.
17, 18, 19, 20, Aphanomyces stellatus.